

SAFETY ASSESSMENT

DOCUMENT

for the

Tandem Van de Graaff Facility

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Tandem Van de Graaff Safety Assessment Document

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1) Introduction

The Tandem Van de Graaff (TVDG) facility, commissioned in 1970, provides low energy heavy ion beams for injection to the Alternating Gradient Synchrotron (AGS) and eventually to the Relativistic Heavy Ion Collider (RHIC) through a beam transfer line completed in 1986 and recently extended to the AGS Booster. The facility also provides light and heavy ion beams for local technological and industrial applications.

The facility is operated by the TVDG Operations and Development Group, which is part of the Brookhaven National Laboratory (BNL) Physics Department. In addition to being governed by the general ES&H programs of the department, the facility maintains a separate branch of the department safety organization, with policies and procedures tailored to the accelerator facility.

The hazards present in the facility are expected to have no more than minor on-site and negligible off-site impacts to people or the environment. The primary hazard is exposure to radiation associated with operation of the accelerator. The Radiation Safety and Access Control System combined with shielding provides appropriate protection for both workers and the public. Hazards are evaluated by the department or facility safety organization with the guidance and oversight of the Safety and Environmental Protection Division (SEP).

2) Summary/Conclusions

The Tandem Van de Graaff Facility is an accelerator facility and is covered by the requirements of DOE Order 5480.25, "Accelerator Safety Order". As per 5480.25, a hazard classification was established using the definitions in DOE Order 5481.1B, "Safety Analysis and Review Systems". The Tandem Van de Graaff Facility is proposing a "low" hazard classification facility based on the information included in Appendix VIII, "Hazard Classification for the Tandem Van de Graaff Facility", which has been submitted for DOE approval.

3) Facility Description: Site, Structures and Operations

3.1) Introduction:

The Tandem Van de Graaff Facility at Brookhaven National Laboratory remains one of the world's largest electrostatic accelerator installations. Approval for this project was granted in 1963, and construction was begun in 1966. High Voltage Engineering Corporation (HVEC) designed and delivered the accelerators, ion sources, and all related beam transport and control systems. Accelerator testing began in January, 1970 and the facility was fully commissioned by June of the same year.

Twin Tandem Van de Graaff accelerators (MP6 & MP7) form the heart of the complex. Each accelerator is enclosed within a large pressure vessel (11,250 ft³) containing an insulating gas mixture at a nominal operating pressure of about 12 atmospheres. The gas mixture is composed of roughly 45% SF₆, 45% N₂, 5% CO₂, and 5% O₂. The mixture is not routinely released as the SF₆ is quite expensive. In fact, the gas is scavenged down to a pressure of 1000 micron (1 torr) prior to backfilling the vessel with air to allow for personnel entry.

A horizontal, in-line arrangement allows operation of each machine independently, or for the use of MP6 as an injector for MP7. Independent, or "two-stage" operation of the accelerators provides the capability for simultaneous experiments to be carried out in separate target rooms. The coupled, or "three-stage" mode makes use of MP6 as the injector for MP7, providing beams of higher energy and intensity than available from

either machine operating alone.

Though originally designed with a maximum terminal voltage of 10 MV, the machines have undergone extensive modifications to enhance their reliability, flexibility, and performance characteristics. Many developments were completely novel, and have since been incorporated into existing machines at other facilities as well as into new production models.

A new phase of operation began in 1986 with the completion of the Heavy Ion Transport Line (HITL) connecting the Tandems to the Brookhaven Alternating Gradient Synchrotron (AGS). For approximately 10 weeks each year MP6 and MP7 would operate in the pulsed mode, providing fully stripped ions up to mass 32 to the AGS for fixed target experiments.

In 1992 construction of the Booster Synchrotron and the HITL to Booster (HTB) Line was completed. The complex of HITL and HTB facilities is formally designated TTB (Tandem to Booster). The Booster is capable of accepting even partially stripped ions and accelerating them to energies up to 0.97 GeV/AMU. After full stripping at these energies, the ions are then injected into the AGS, enabling acceptance of the entire mass range available from the Tandem Facility. Future plans include the construction of the Relativistic Heavy Ion Collider (RHIC) which will allow for collision of like or different ion species at energies up to 100 GeV/AMU (Au). The AGS and RHIC are administratively separate from the Tandem Van de Graaff Facility and require separate Safety Analysis Reports.

As one of the premier heavy ion facilities in the world, the Tandem Van de

Graaff Facility at BNL will continue operations through the 1990s. With no practical alternatives apparent for the near future, the Tandems remain the only viable source of pulsed heavy ion beams for the AGS and RHIC experimental programs. When not serving as an injector for the AGS, the Tandem Van de Graaff facility remains one of the most reliable and versatile sources of heavy ions in the world, and is available to users from BNL, industry and universities.

3.2) Building Site:

The Tandem Van de Graaff Facility at BNL consists of two major structures: Building 901A and the TTB (Tandem to Booster) complex. An aerial view of the installation showing its relation to the lab site appears in Figure 3-1. The shortest distance from Building 901A to the site boundary is approximately 1 mile.

Building 901A is situated along Cornell Avenue, attached at its west end to the older section of the 901 building, and extending approximately 382 feet east to the edge of the High Flux Beam Reactor (HFBR) grounds. The building was excavated from a hill with an approximate 15° incline, rising north from Cornell Avenue and cresting at Building 704 (the fanhouse for the decommissioned Graphite Reactor). The top of the hill was regraded to extend earth cover over the accelerator and target room areas of Building 901A.

Since the original construction, four additions have been made to the structure. Two involved new office and lab space at the west end of the building. The third and fourth were the construction of the HITL and HTB facilities which form the TTB

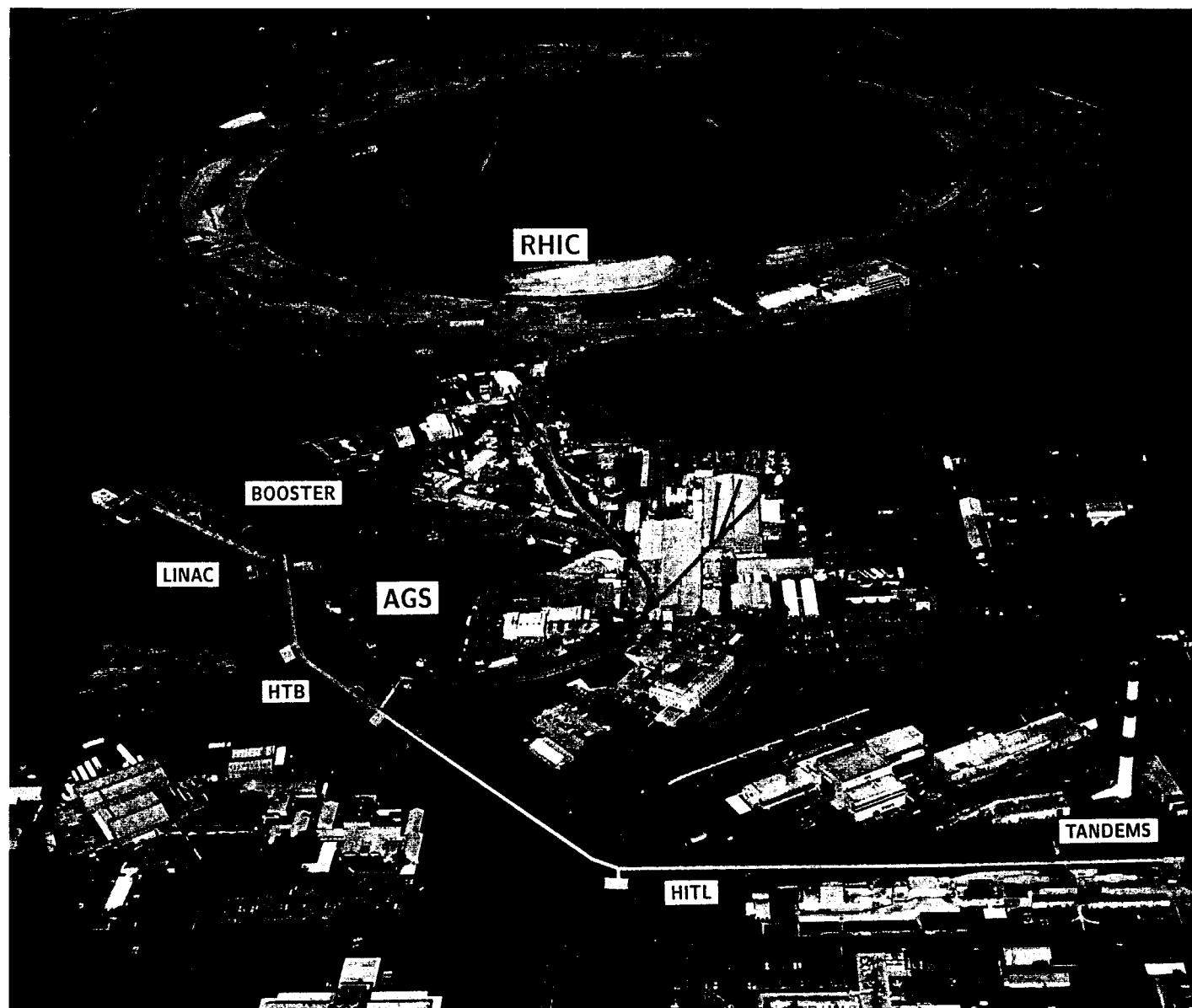


Figure 3-1

Aerial view of the Tandem/TTB complex and related structures. The TTB tunnel is labeled with the names of its components, HITL and HTB.

complex. The TTB complex comprises approximately 2800 linear feet of tunnel housing the TTB beam lines, associated transport and control equipment, and three power supply houses located at intermediate points along the line. SARs exist for these facilities, and they are not discussed further in this document.

3.3) Building 901A Services and Utilities:

3.3.1) General: The structures described in section 3.4 all provide the following standard building services: normal lighting systems, emergency lighting, 120 VAC power receptacles, telephone, PA system, normal HVAC service, and fire detection. Domestic water, deionized water, chilled water, compressed air, 208 VAC and 480 VAC, emergency exhaust ventilation and fire suppression are also available in certain areas. The maintenance and repair of all systems except deionized water is performed by Plant Engineering, Instrumentation, or telephone contractor. The deionized water system is maintained by the Tandem Van de Graaff Facility.

3.3.2) Electrical Distribution: Power distribution in 901A originates in two separate locations. At the N1 substation, one of two switchable 1 MVA, 3 phase transformers provides redundant 480 VAC from the main 13.8 kVAC feeder. The 480 VAC is then distributed to the main building transformers in the Building Equipment Room, as well as to motor control centers and power distribution centers in other parts of the building. Adjacent to the N1 substation, a 2 MVA, 3 phase transformer supplies 2.4 kVAC from the 13.8 kVAC feeder. The 2.4 kVAC is distributed by switchgear in

Building 901, with one circuit delivering this power to the N18 panel in the 901A Building Equipment Room. This power source is used solely by the building's two water chillers and is not distributed elsewhere in 901A.

3.3.3) Heating, Ventilation and Air Conditioning: Conventional HVAC services are available to all original areas of Building 901A. The building is subdivided into six zones, five of which are provided with local control panels. Manually activated emergency services are also provided at these panels including the ability to isolate an area affected by smoke or other noxious fumes and to initiate an emergency exhaust system to clear the affected area. Nominal air flow in each zone is approximately 2,080 CFM. In the exhaust or "purge" mode, an additional purge fan is brought on line which increases air flow up to 23,010 CFM. The newer office structures at the west end of 901A have local HVAC and air handling equipment. The building was constructed without smoke detector shutdown of air handling equipment. As per NFPA 90A Chapter 4, no retrofit is required.

3.3.4) Fire Detection and Protection: Fire detection systems include smoke, rate of rise, and fixed temperature sensors throughout Building 901A. Fire protection systems include sprinklers, Halon discharge, hand held extinguishers and local pull boxes. Not all detection and protection systems are provided in each area of the building. Additional details about protection of specific building areas is included in Section 4.1.3 and in Appendices II and III. Plans to replace the Halon systems are covered in the Brookhaven National Laboratory Halon Phase-out Study dated October 14,

1994.

3.3.5) Normal and Emergency Lighting: Normal lighting services include standard fluorescent fixtures located throughout Building 901A and controlled locally. Also standard throughout the experimental and accelerator areas are background lights which remain on at all times. Emergency lighting is provided by battery pack light units which charge continuously and activate upon loss of building power. These units are located at strategic points in and around the facility and are maintained by Plant Engineering.

3.3.6) Public Address (PA) System: Two public address systems have been installed. One covers the areas of Building 901A used by the Tandem Operations Group as well as the TTB complex; the other covers some laboratories and offices at the west end of the building. The systems are used both for general announcements and to provide notification of an emergency situation to building occupants. The Control Room Console has the ability to link the two systems for emergency purposes. Announcements for the first system can be made from four locations: the Control Room console, the main lobby office, Lab 3, and the west end of Accelerator Room 1. Additionally, access is available from any telephone via the lab paging system (x0798). However, because this system queues messages as they are received, there is some delay before an announcement reaches the PA system.

3.3.7) Water and Air Systems: Domestic water is available in various areas of Building 901A for use as needed. Chilled water is supplied by two water

chilling units for use by the accelerator heat exchangers, insulating gas compressors, and by the building air conditioning units, but is not otherwise generally available. A closed loop deionized water system supplies water for cooling beam line and ion source components as well as larger magnets. Compressed air is provided in many locations, but is generally used to actuate beam line components in the accelerator and target rooms.

3.4) Building 901A Structures:

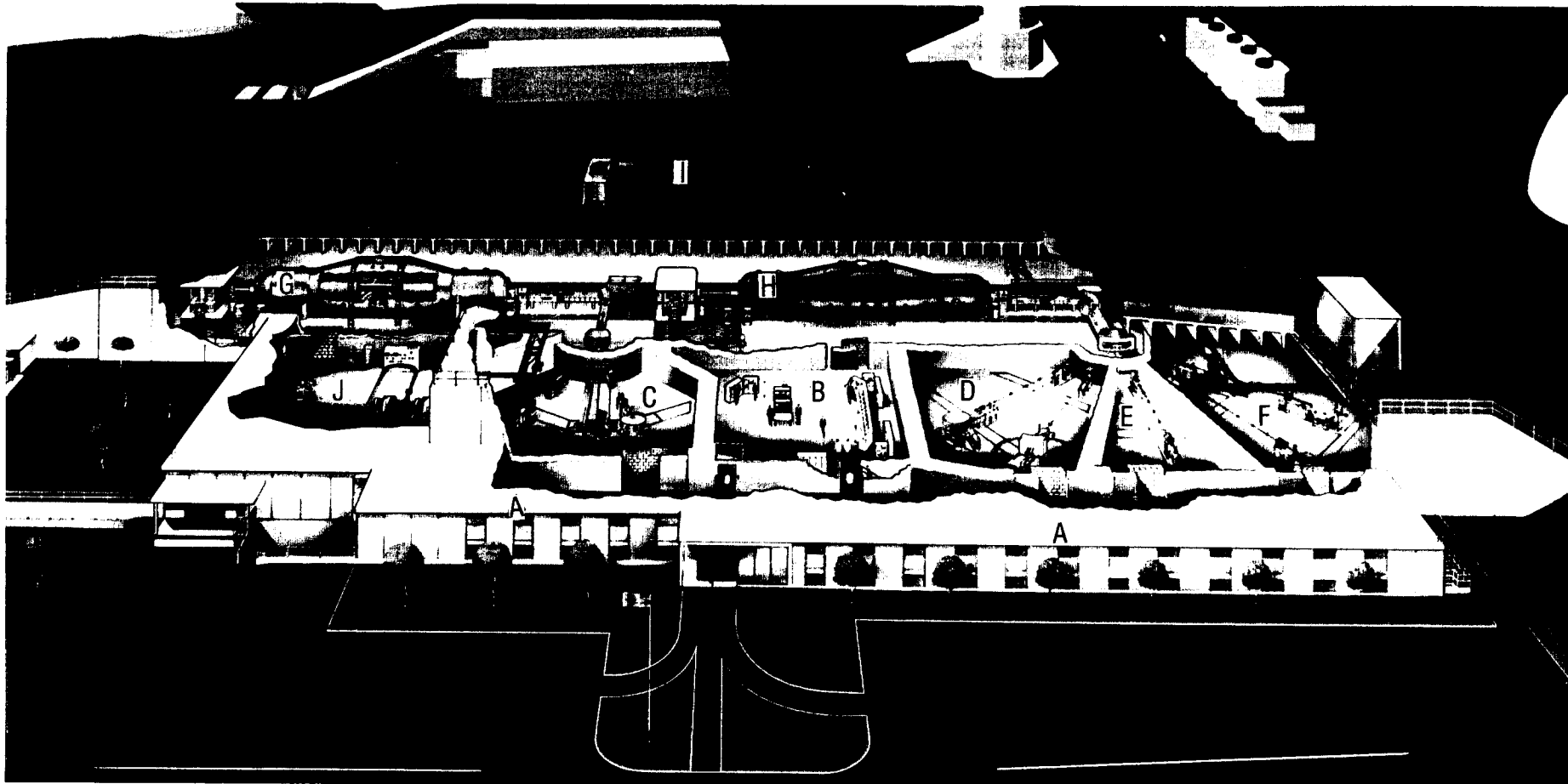
3.4.1) General: Architectural plans for Building 901A were designed by the Catalytic Construction Company, Philadelphia, PA. Starrett and Ekin was the lead contractor during the construction phase. Detailed design of the structures is not described here, but can be found in the original Catalytic Construction Co. drawings on file in Building 901A and with the Plant Engineering Division. The following sections will however provide a summary of the major building structures. Figure 3-2 shows a cut-away view of the building for reference.

3.4.2) Accelerator Rooms 1 & 2:

3.4.2.1) Description: The designations 1 and 2 are for operational purposes only, as the "two" rooms actually form one large accelerator vault approximately 318 feet long, 35 feet wide, and 25 feet high. Accelerator Room 1 refers to the west half of the structure where MP6 is located, and Accelerator Room 2 to the east half where MP7 is located. A pit 10 feet deep extends out 18 feet from the north

wall and runs the length of each room. The two pits are joined by a short passageway which is also common to the EE Room, and a second passageway joins the MP6 pit to the ME Room. Steel grating or decking covers these pit areas. Entry and exit points are: 1) Accelerator Room 1 shielding door, 2) Pit 1 passage to ME Room, 3) Accelerator

Tandem Van de Graaff Facility-Building 901A



A) Offices & Labs
B) Control Room
C) Target Room 1
D) Target Room 2
E) Target Room 3

F) Target Room 4
G) MP6 Accelerator
H) MP7 Accelerator
I) Insulating Gas Storage
J) Mechanical Equipment (ME) Room

Not Shown:

- 1) Building Equipment (BE) Room
- 2) Electrical Equipment (EE) Room
- 3) Modular Additions

Figure 3-2

Room 2 shielding door, 4) Pit center passage to EE Room, 5) Accelerator Room 2 passage to TR4, 6) TTB penetration point.

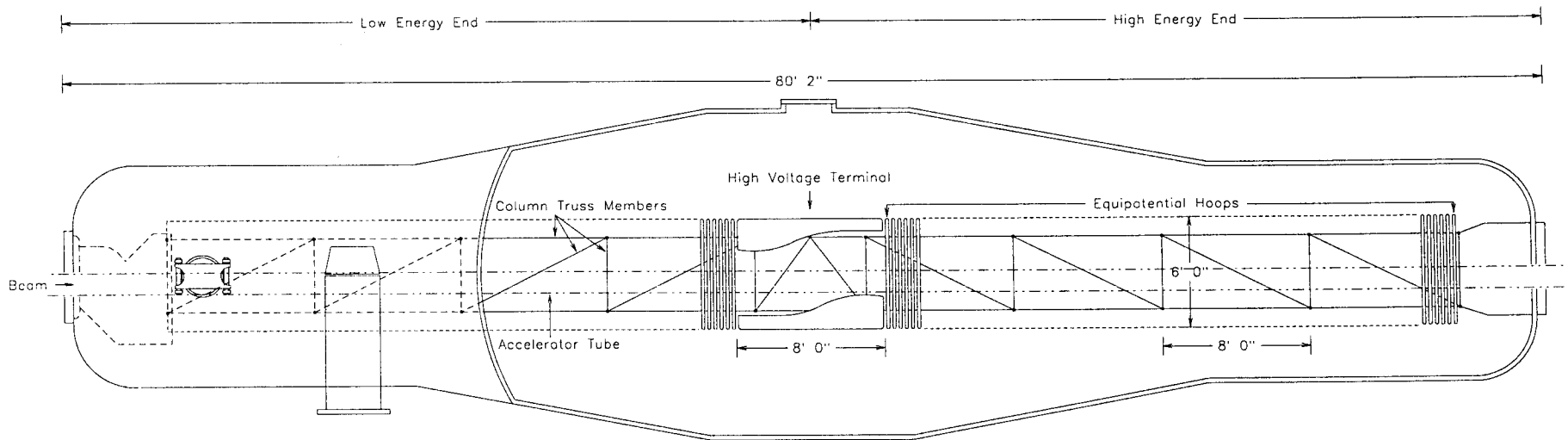
3.4.2.2) Services & Utilities: Standard services are as described in Section 3.3.1 . Other systems provided are 3 phase 208 VAC power, domestic water, deionized water, and compressed air, and a vacuum exhaust system. 400Hz 120 VAC and 208 VAC are also available from a motor-generator set located in the Building Equipment Room. A 7.5 ton overhead crane is provided for moving large pieces of equipment.

3.4.2.3) Equipment: The twin accelerators, MP6 and MP7, dominate the room with pressure vessels each approximately 80 feet long and diameter varying from 12 feet at the ends to 18 feet at the center (Figure 3-3). Other major equipment includes two 300 kVDC negative ion injectors, accelerator beamlines and beam diagnostic equipment, several large dipole magnets and magnetic quadrupole doublets, and a number of magnetic and electrostatic steerers.

Support equipment includes a wide variety of power supplies, control electronics and vacuum equipment, as well as recirculators, dryers, filters, piping and valving for the accelerator insulating gas handling system.

3.4.2.4) Radiation Sources: Both the MP6 and MP7 pressure vessels have provisions for attaching a lead pig which can be used to hold a radioactive source. Insertion of this source into the vessel opposite the machine's terminal region generally improves the voltage holding ability and voltage stability. When not needed,

HVEC Model MP Tandem Van de Graaff Accelerator



General Physical Data:

Total Weight:	375,000 lb
Volume:	11,250 ft ³
Nominal Pressure:	12 atm

Figure 3-3: MP Accelerator Structure

the source can be fully withdrawn and shielded within the pig so that personnel may safely enter the pressure vessels.

Details regarding the specific isotope used ($_{55}\text{Cs}^{137}$) and the associated hazards involved are discussed in the Risk Assessments for Section 4.2.1 (Accelerator Room Systems).

3.4.3) Tandem Control Room:

3.4.3.1) Description: The Tandem Control Room serves as a central point for monitoring and control of all accelerator operations. Entry and exit points include the Accelerator Room 2 shielding door, the main hallway door and the service elevator, which opens to both the control room and main hallway.

3.4.3.2) Services and Utilities: Standard services and utilities are as described in Section 3.3.1 . Other systems include fire protection and isolated 120 VAC power. Fire protection is provided by a Halon system with discharge points located under the floor panels and in the ceiling. Isolated 120 VAC power and ground are supplied by an electrostatically shielded "quiet power" transformer (N16) located in the Building Equipment Room.

3.4.3.3) Equipment: The main operator control console stretches the length of the east wall, with a line of control and instrumentation racks directly behind it. The HITL control console sits directly opposite the main console and is only one third as long. A number of patch panels are located along the south and west walls, bringing signal and control lines from various points in the accelerator and target rooms.

A floating floor provides equipment ventilation and access to cable runs.

3.4.4) Target Rooms:

3.4.4.1) Description: Four separate target rooms exist in the facility.

Three remain as active target rooms, and one, TR3, is no longer in use as a target area. Several distinct beam lines are available in each active target room, providing a great deal of flexibility to experimenters. Covered trenches provide access to cable runs and utility services. Each room has a 30 ton steel shielding door for entry and exit from the main corridor. In addition, TR4 also has an escape passage from Accelerator Room 2 located at its north-west corner. The shielding door is approximately 3 feet thick; the walls between adjacent target rooms are approximately 4 feet thick; the walls separating the target rooms from the corridor are approximately 6 feet thick.

3.4.4.2) Services & Utilities: Standard services are as described in Section 3.3.1 . Other systems available are 3 phase 208 VAC power, domestic water, deionized water, and compressed air. 3 phase 480 VAC is available but not distributed. The three active target rooms each have a 3 ton overhead crane for moving large equipment.

3.4.4.3) Equipment: The only fixed equipment in the three active target rooms are the beam lines and associated beam transport components. Patch panels provide signal and control cables from the Control Room.

TR3 contains power supplies and control equipment for HITL. It also provides work space for technicians and storage space for hardware.

3.4.5) Mechanical Equipment (ME) Room:

3.4.5.1) Description: The ME Room contains a variety of equipment related to accelerator and building support functions. Entry and exit points are the Accelerator Room 1 shielding door, the passageway to Pit 1, the east and west hallway doors, and the west office hallway via the ion source lab.

3.4.5.2) Services and Utilities: Standard services are as described in Section 3.3.1. Other services include 208 VAC power, domestic water, and compressed air. 480 VAC power is provided to two power distribution and motor control centers.

3.4.5.3) Equipment: Major equipment in the Mechanical Equipment Room are the accelerator gas handling equipment, machining tools, a five ton hand hoist, deionized water supply system, LN₂ (Liquid Nitrogen) storage dewars, two electrical distribution and motor control centers, and a soldering bench.

The accelerator gas handling equipment includes two Norwalk 150 HP, three stage compressors, a Kinney KT-850 vacuum pump with two blowers attached, a water heater operating on low pressure steam, and the gas handling system control panel.

A small machine shop provides most standard machining tools, including lathes, band saws, a drill press, a milling machine, a bead blaster, grinders, shears, punches, and so forth.

The deionized water system supplies deionized water to building 901A and the TTB complex. Equipment includes deionizing beds, circulating pumps, flow control

valving, and expansion and overflow tanks. Waste effluent produced from the reactivation procedure was been analyzed and shown to contain heavy metals beyond limits allowed for discharge to the sanitary waste system. Therefore, it is planned that in the future the resin bed will be disposed of as hazardous waste rather than being reactivated.

Two electrical distribution and motor control centers provide 480 VAC and 208 VAC power for all equipment in the ME Room, as well as to certain equipment in the Accelerator and Building Equipment Rooms.

3.4.6) Building Equipment (BE) Room:

3.4.6.1) Description: The Building Equipment Room, located on the south side of the basement, contains equipment serving building support functions. Entry and exit points are the east and west exterior stairwell doors, and the stairway to the 901A main hallway. The BE Room is the only area of Building 901A approved for storage of combustibles because it is protected by a sprinkler system.

3.4.6.2) Services and Utilities: Standard services and utilities are as described in Section 3.3.1. Other services include domestic water, closed loop chilled water, "tower water" (a closed loop water system running between the building HVAC equipment and the roof top cooling towers), and fire protection provided by a sprinkler system. Three phase 480 VAC power is distributed to an electrical distribution and motor control center, and to the building electrical distribution transformers. As previously described, a three phase 2.4 kVAC circuit delivers power to the two building

water chillers.

3.4.6.3) Equipment: Major equipment located in the BE Room are the building HVAC equipment and water chillers, electrical distribution transformers, several air compressors, a 10 kVA 400Hz motor-generator set, a 5 kVA 60 Hz motor-generator set which powers the TVDG radiation safety system, and an electrical distribution and motor control center.

HVAC equipment includes six "air handlers" which provide climate control and ventilation to the six HVAC zones in building 901A. Five of these units provide emergency exhaust ventilation via a common exhaust fan.

There are four power distribution transformers in the BE Room. All are fed from the main 480 VAC distribution buss at the N1 substation, and supply 208/120 VAC power to areas in Building 901A.

Three compressors provide oil free compressed shop air (100 scfm at 100 psi). A Worthington monorotor compressor rated to deliver 240 scfm at 120 psi is available to provide high capacity compressed air for experimental use.

3.4.7) Electrical Equipment (EE) Room:

3.4.7.1) Description: The EE Room, located in the basement, contains accelerator related electrical equipment and personnel work space. Two small offices are also located within the room as well as a number of desks and benches for technicians. Personnel entry and exit is through a stairway to the 901A main hallway. Cable tray passageways lead to the accelerator pit area, and through the stairwell to the

Building Equipment Room and the Control Room.

3.4.7.2) Services and Utilities: Standard services and utilities are as described in Section 3.3.1. Other services include isolated 120 VAC power and fire protection. Isolated 120 VAC power is supplied from the N16 "quiet power" transformer in the BE Room. Fire protection is provided by a Halon discharge system located under the floor panels.

3.4.7.3) Equipment: Two power distribution centers deliver single phase 120 VAC, and three phase 208 VAC and 480 VAC to MP6 and MP7 accelerator equipment. Two rows of stand up cabinets accommodate DC power supplies for the MP6 and MP7 dipole and quadrupole magnets. Also found in these cabinets are the relay logic for the accelerator equipment interlock system and for the radiation protection system. A small concentration of computer equipment as well as the building PA system amplifier electronics are also located in the EE Room. A floating floor provides equipment ventilation and access to cable runs.

3.4.8) Offices and Labs:

3.4.8.1) Description: There are three distinct office and lab areas located in Building 901A. The original 901A area accommodates eight offices (plus the two in the EE Room) and three labs. One extension and one modular structure at the west end of the building added new office space, a conference room, and three labs, one of which is used as an ion source lab and 90 day hazardous waste accumulation area.

3.4.8.2) Services and Utilities: Standard services and utilities are

as described in Section 3.3.1 . Other services in the labs include domestic water, compressed air, and 208 VAC power distribution. 400Hz power is provided in Lab 3.

3.4.8.3) Equipment: No experimental, accelerator support, or building support equipment is located in the office areas of Building 901A. Contents of labs vary with use. Storage and use of hazardous substances in the labs is subject to review and approval by the Tandem Safety Committee. Surface coating is allowed in the hoods in Labs 1 and 2. No air emissions permit is required. (See BNL memo "Building 901A Paint Hood Exhaust (Emission ID No. 90102)" from J. Williams to J. Throwe, dated March 22, 1993.)

3.4.9) Insulating Gas Storage Facility:

3.4.9.1) Description: The Insulating Gas Storage Facility is located atop the hill which rises north from the Building 901A roof and crests at Building 704 (the decommissioned Graphite Reactor fan house). The structure is completely separate from the 901A structure. It consists of two opposing banks of high pressure gas storage cylinders with an intervening concrete structure allowing access to the gas piping and valving system. Each bank consists of three buried layers of cylinders separated by earth, with the upper layer 42 inches below grade. Due to excessive deterioration, the concrete portion of the structure was rebuilt in 1990.

3.4.9.2) Services and Utilities: The only services provided are 120 VAC, normal lighting and emergency lighting.

3.4.9.3) Equipment: Equipment is limited to the gas piping and

valving system and a sensor for the insulating gas detection system.

3.5) Organization and Operations:

Operation of the TVDG Facility is the responsibility of the Tandem Operations Group of the BNL Physics Department. The most recent departmental organizational chart, and a facility organizational chart are included as Figures 3-4 and 3-5. The TVDG Group Leader is the highest ranking individual familiar with the day-to-day operation of the TVDG facility. He is responsible for development and implementation of the facility program. The Operations Supervisor, who appears in the TVDG organizational chart in the block labeled Accelerator Development, Maintenance and Operation, is responsible for operation and maintenance of the accelerators and supervision of accelerator operators. He also acts as liaison to the outside users of the facility.

The TVDG Conduct of Operations Program provides guidelines for operation of the TVDG program. A conformance matrix has been completed to show how the facility meets the requirements of the associated DOE Order.

3.5.1) ES&H Organization

In addition to site-wide ES&H programs that will not be discussed in this document, the Physics Department and the Tandem Van de Graaff Facility have instituted programs, procedures and management systems.

3.5.1.1) Physics Department ES&H Program: The Physics Department ES&H program governs the operation of Building 901A and of the Tandem

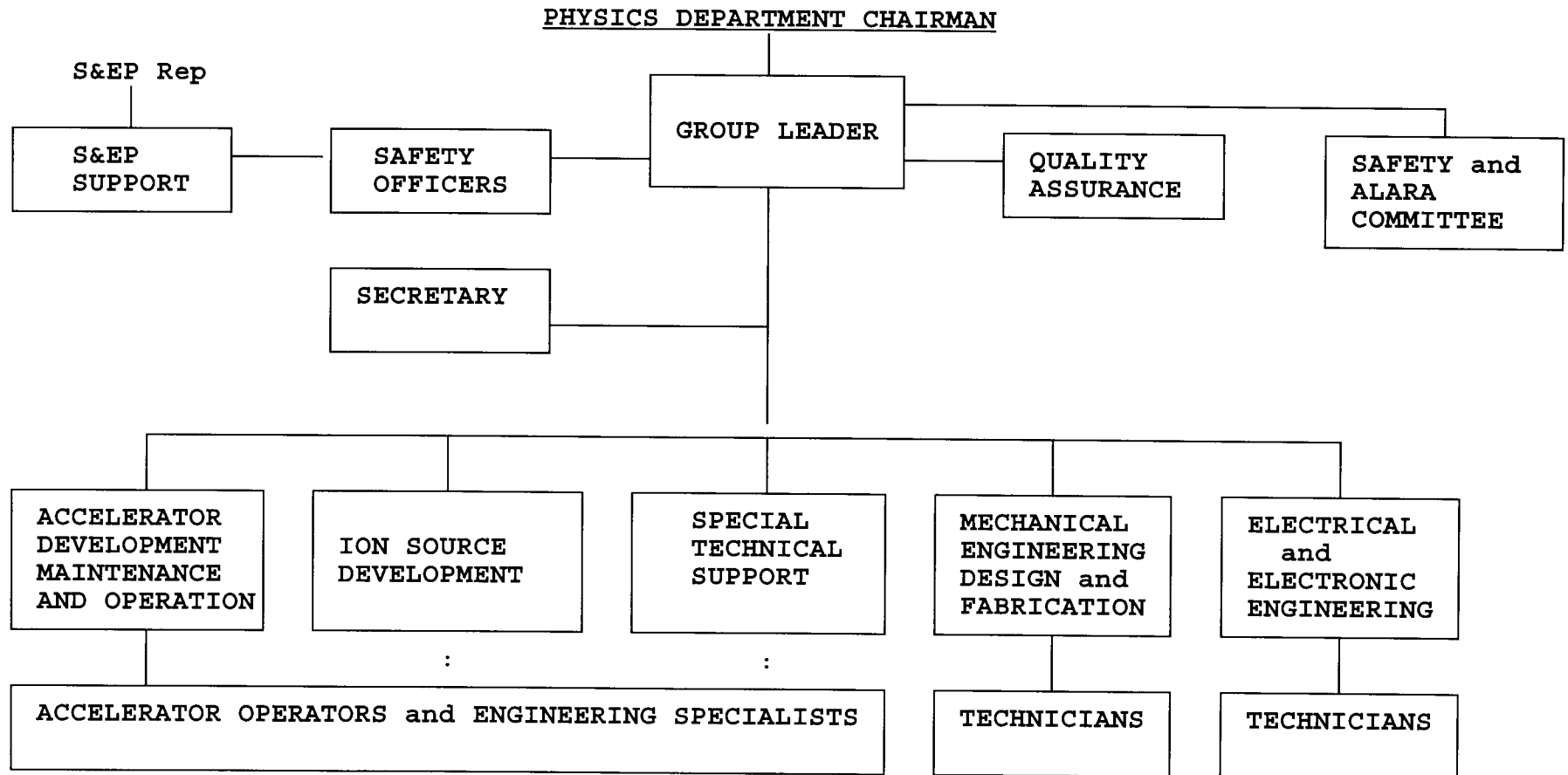
Operations Group. Some program elements are common to Building 901A and the main portion of the department in Building 510. However, unique ES&H concerns related to the presence of the accelerators have made it advantageous for Building 901A to maintain a separate branch of the department safety organization, with policies and procedures specific to that building. The Building 901A ES&H Coordinator and the Building Manager serve as members of the department ES&H Committee, which reviews departmental ES&H concerns. The Physics Department Safety and Environmental Administrative Policy and Procedures Manual (SEAPPM) covers the Tandem Van de Graaff, either jointly with the rest of the department or in separate TVDG procedures. The Physics Department Training Plan identifies TVDG operators as belonging to a critical job classification, and a DACUM (Develop a Curriculum) and a Job Training Assessment have been completed by the Laboratory Personnel Division.

3.5.1.2) Building 901A ES&H Program: The Tandem Safety Committee is responsible for ES&H review of experiments, activities and equipment within Building 901A and associated structures. The committee includes members with detailed technical knowledge of the entire accelerator system. A member of the Safety and Environmental Protection Division also serves on the committee. Items requiring review are brought to the attention of the committee by the principal investigator or, in the case of users of the accelerators, by a screening questionnaire submitted to the Operations Supervisor. The scope of user applications is very limited and committee review of their activities is rarely necessary.

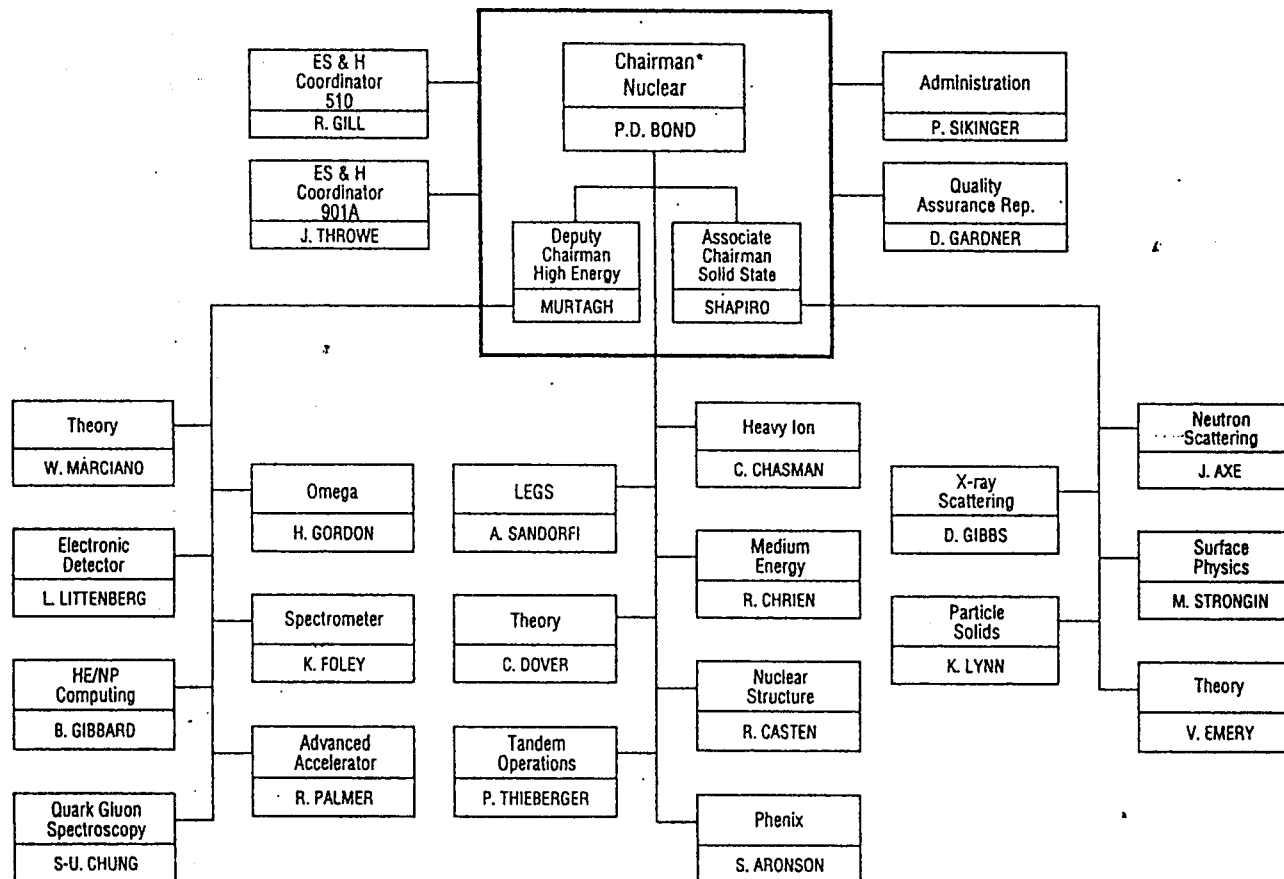
3.5.1.3) Safety support services: The Safety and Environmental

Protection Division maintains a presence within the TVDG facility through a representative who is resident within the Building 901 complex. This individual serves as the liaison with the TVDG Operations Group and works closely with the TVDG staff on safety matters. Complementary coverage for the Physics Department is provided by an additional representative resident in Building 510. These individuals report to the Physical Sciences Group Leader within the Facility Support Section of S&EP.

TANDEM VAN DE GRAAFF OPERATIONS AND DEVELOPMENT GROUP



PHYSICS DEPARTMENT



*Reports to Associate Director HE/NP

APPROVED:

P.D. Bond

P.D. BOND
10/1/94

4) Systems: Design Criteria, Hazard Identification and Mitigation

4.1) General Facility Systems

4.1.1) Radiation Safety and Access Control System

4.1.1.1) Introduction: By its very nature, the TVDG Facility has a complex and varied capability for producing radiation depending on the type of ion being accelerated. Energies of Tandem accelerated ions are proportional to the charge state achieved by the ions when they undergo stripping within the accelerator. Because the lighter ions can be stripped to charge states comparable to their atomic numbers, they can achieve a relatively high energy per nucleon and as such are capable of producing appreciable numbers of fast neutrons and associated gamma rays when they strike a target. Heavier ions cannot be stripped to charge states comparable to their atomic number and thus can only attain a relatively low energy per nucleon. Such particles do not produce nuclear reactions when they strike a target, and thus produce no appreciable radiation field. As a result of this diverse capability for producing radiation, a very dynamic and flexible safety system has been devised. The systems to be described in the following sections allow maximum access to accelerator equipment while maintaining automatic surveillance and complete radiation safety for personnel in full accordance with established guidelines.

The Radiation Safety and Access Control System protects people in the Accelerator Rooms and Target Rooms. The maximum dose rates that TVDG beams can produce outside of these areas are described in Appendix IX, "Building 901A Shielding Effectiveness Studies".

4.1.1.2) Delegation of Responsibilities: Responsibilities for radiation control are assigned in the document "Tandem Van de Graaff Radiation Control Responsibilities". (Appendix I)

4.1.1.3) The Radiation Safety and Access Control Sub-Systems: The TVDG Radiation Safety and Access Control Sub-Systems have been designed in such a way as to allow maximum access to the accelerators and experimental areas while conforming to ALARA and radiological control policies. Entry into beam related High Radiation Areas (>100 mR/hr) is normally prohibited. Although the Facility Group Leader could authorize bypassing of the interlocks of the Radiation "Zone" Control System described in II below to allow such entry, it is not anticipated that there would ever be reason to do so. High Radiation Area entry requirements detailed in Section 334 of the BNL Radiological Control Manual would also need to be met. Entry into Accelerator Room and Target Room areas with radiation levels less than 100 mR/hr is allowed subject to the combination of interlocks and administrative controls described below.

Logic diagrams of the Radiation Safety and Access Control System are included as Appendix IV. Radiation Safety and Access Control is divided into sub-systems:

I) Machine Perimeter: This sub-system enhances facility safety and security by ensuring that access to the accelerator rooms is obtained only via the Control Room entrance or an entrance under administrative control of an operator. It should be noted that entry to the Accelerator Rooms is also controlled by locking all entrances except for the Control Room entrance. The machine perimeter sub-system provides an additional level of security. A specific perimeter is established using interlocked doors or gates at entry points. Personnel wishing to enter an area of the accelerator rooms where accelerators and beamlines are active must enter only through the Control Room entrance with the permission of a TVDG Operator. The TVDG

Operations Procedures Manual (OPM) contains detailed procedures for establishing an active perimeter (TVDG OPM Procedure XIV). Beam can only be accelerated when a perimeter has been established around the active areas. The active perimeter is indicated on the system status panel. Should entry be made through an interlocked access point, the perimeter control system will automatically insert beamstops and generate visible and audible signals on the status panel in the TVDG Control Room. The TVDG OPM contains detailed procedures to be followed in the event of a perimeter violation (TVDG OPM Procedure XVI). A TVDG Operator will investigate and remedy the perimeter violation in accordance with the TVDG OPM, reset the Radiation Safety and Access Control System status, and re-establish beam. The perimeter control system thus ensures that the Operations Staff has full control over access to the Accelerator Rooms.

II) Radiation "Zone" Control: Within the Accelerator Rooms and Target Rooms, specific radiation protection zones have been established. Entry points to these zones are surveilled using a combination of interlocked doors, gates, or light beams. The accelerator rooms are divided into eight controlled zones: MP6 LE and HE (Low Energy and High Energy) main level, MP6 LE and HE pits, MP7 LE and HE main level, and MP7 LE and HE pits. Each Target Room, each pit level passageway, and the main level passage from TR4 to MP7 are considered as individual zones. A given zone is defined by interlocked entry points which may be gates, doors, or light beams. The TVDG OPM contains detailed procedures for securing zones (TVDG OPM Procedure XV). Zones are secured by performing an enforced sequence search. After a zone has been swept, a zone may be exited via an appropriate point where a final inspection station button is then depressed, activating the zone. A secure zone is then an exclusionary area where radiation in excess of Radiation Safety System setpoints does not trip interlocks so long as the zone remains secured. Zone status is indicated on the system status panel.

III) Active Area Monitoring: Radiation zones are

continuously monitored by area radiation monitors regardless of whether that zone is interlocked. In the Accelerator Rooms, an area monitor is located within each of the four main level zones. Each detector serves as a common monitor for a main level zone and the corresponding pit level zone below it. Each Target Room also has a radiation area monitor. The passageway zones have no area monitors. They are simply treated as exclusionary areas during machine operation and must be secured to permit beam acceleration.

There are four basic radiation conditions (FAILSAFE, GREEN, AMBER, and RED) for the monitored zones. Radiation Safety System responses depend upon the status of a zone and the radiation level seen by the monitor for that zone:

A) Zone Condition FAILSAFE:

1) Radiation Condition: Radiation levels are unknown due to a monitor failure.

2) System Responses: A failsafe condition is treated as a RED radiation condition (See **Zone Condition RED**).

B) Zone Condition GREEN:

1) Radiation Condition: Radiation levels are between background and 5 mR/hr. A zone whose status is GREEN is not exclusionary and need not be secured.

2) System Responses: The system status panel in the Control Room will light a green lamp for the corresponding zone.

C) Zone Condition AMBER:

1) Radiation Condition: Radiation levels are between 5

mR/hr and the current AMBER/RED transition set point which may not exceed 100 mR/hr. A zone whose status is AMBER is not exclusionary and need not be secured.

2) System Responses: The system status panel will light an amber lamp for the corresponding zone, and the system will light an amber rotating beacon located in a highly visible area of the zone. This serves to warn personnel that radiation is present.

D) Zone Condition RED:

1) Radiation Condition: Radiation levels are above the AMBER/RED transition set point, which may not exceed 100mR/hr. A zone whose status is RED is exclusionary and must be secured and interlocked to permit accelerator operation.

2) System Responses: The system status panel will light a RED lamp for the corresponding zone. If the RED condition exists in either the MP6 or MP7 HE Zone, the system will activate a red rotating beacon located in a highly visible area of that zone. Other system responses depend on the zone interlock status:

i) Zone Secure: If the zone has been searched and secured prior to the onset of a RED radiation condition, no further response is generated other than that listed above. A secure zone is exclusionary and so high radiation levels may exist without danger to personnel.

ii) Accelerator Zone not Secure: If an accelerator zone has not been searched and secured prior to the onset of a RED or FAILSAFE radiation condition, or if a secure zone entry point is violated with the zone in a RED or FAILSAFE condition, the system will immediately insert

beamstops, shut down the accelerator involved, and shut down the PRE-ACCEL voltage of the Ion Injector for that accelerator. The system will generate visible and audible signals on the system status panel indicating a "Radiation Without Interlock" condition.

iii) Target Room not Secure: If a Target Room has not been swept and secured prior to the onset of a RED or FAILSAFE radiation condition, or if a secure entry point is violated with the Target Room in a RED or FAILSAFE condition, the system will immediately insert a beamstop in the accelerator room to remove beam from the Target Room. For TR1, both the MP6 HE and Image Faraday Cups are inserted. For TR2 or TR4, the MP7 HE and Image Faraday Cups are inserted. The redundant response will remove beam from the affected Target Room. The system will generate visible and audible signals on the system status panel indicating a "Radiation Without Interlock" condition.

The TVDG OPM contains detailed procedures to be followed in the event of a Radiation Without Interlock response by the Radiation Safety System (TVDG OPM Safety Appendix Procedure VI).

4.1.1.4) Emergency Stops: A final level of personnel protection is provided for by the presence of emergency stop buttons located throughout the Accelerator and Target Rooms and in the Control Room Area. These are large, illuminated, red pushbuttons labelled with "EMERGENCY STOP" signs. Should a person have cause, he can activate the nearest switch. System response to an emergency stop activation depends on the area in which the button is pushed:

I) Accelerator or Control Room: This will immediately cause insertion of all faraday cups (beamstops), a complete shutdown of both accelerators and their associated ion injectors, and generate audible and visible

signals on the status panel.

II) Target Rooms: This will cause only insertion of faraday cups (beamstops) in the corresponding accelerator room, and generate audible and visible signals on the status panel.

The TVDG OPM contains detailed procedures to be followed in the event of an emergency stop button being activated (TVDG OPM Safety Appendix Procedure V).

4.1.1.5) Security System Bypassing/Reconfiguration: The Radiation Safety and Access Control System was designed with provisions for bypassing certain responses. These reconfigurations are affected using selected "Bypass Switches" located near the system status panel. The system status panel displays a large warning message when any "Bypass Switch" is active. These switches require key access and are used only as detailed in the TVDG OPM (TVDG OPM Operations Procedures Appendix Procedure XXIII). Procedures for their use are in accordance with BNL ES&H Standard 3.4.0, Section IV.C.1.e. "Bypassing the Security System". The Physics Department Chair has delegated responsibility for authorizing bypassing/reconfiguration of the security system to the Facility Group Leader. (Memo from P. D. Bond to P. Thieberger dated December 4, 1992.)

4.1.1.6) Hazard Identification and Mitigation: There are no specific hazards identified for this system. Radiation hazards specifically mitigated by the Radiation Safety and Access Control System are documented in the risk assessment evaluations and are grouped by facility area.

4.1.1.7) Operational Safety Limits: In accordance with BNL ES&H Standards 1.3.3 and 1.3.4, one operational safety limit has been established to

ensure personnel protection in accordance with TVDG ALARA guidelines and proper safety system operation. This OSL is OSL_RADSAFE_1. The intent is to ensure safe operation of the accelerators and that the integrity of the TVDG Radiation Safety and Access Control System is not breached by system malfunction or unauthorized modification.

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_RADSAFE_1

SYSTEM: Accelerators

SUBSYSTEM: Radiation Safety and Access Control System

PURPOSE OF OPERATIONAL SAFETY LIMIT: To ensure that radiation exposures related to operation of the Tandem accelerators do not exceed Administrative Control Levels.

1) SAFETY LIMIT:

None.

2) DESIGN FEATURES:

A) The TVDG Radiation Safety and Access Control System:

1) This system monitors radiation dose rates in potential Radiation Areas and prevents access to High Radiation Areas. The system is immune to short term power interruptions, and long term power interruption will cause it to revert to a failsafe condition.

2) Gamma monitors rely on a low level signal to verify their operability. Should the monitor fail to detect this signal, the system places that radiation protection zone into a failsafe mode.

3) The system limits the maximum radiation field in a non-secured, non-interlocked controlled area to 100 mR/hr.

B) Shielding is in place to minimize radiation exposures. The effectiveness of shielding is tested under extreme operating conditions.

3) ADMINISTRATIVE CONTROLS:

A) The TVDG Radiation Safety and Access Control System:

- 1) No modification to any system function is allowed without the approval of the Cognizant Engineer. Any planned deviation from normal system operation must be with the approval of the Cognizant Engineer. He/she must refer any significant changes in system function or operation to the Tandem Safety Committee for review.
- 2) Radiation monitors are calibrated to a NIST traceable standard every twelve months.
- 3) System functionality and responses are tested semi-annually using procedure "Radcheck".
- 4) If the integrity of the Radiation Safety System becomes impaired or suspect in any manner relevant to the mode of machine operations, all accelerator beamstops must be immediately inserted. The TVDG Group Leader or his designate must be notified of the situation. Accelerator operations may resume only after the TVDG ALARA Officer or his designate determines whether sufficient safeguards remain in place to ensure compliance with current BNL radiological regulations.

B) The Tandem Safety Committee reviews the results of shielding studies in conjunction with S&EP and evaluates the need for additional shielding or changes in postings.

C) Film badges are required for entry to Target Rooms and Accelerator Rooms. The Tandem Safety Committee reviews any significant radiation exposure to Tandem personnel recorded by film badges.

D) As part of their training and certification, TVDG Operators must demonstrate an understanding of the causes and forms of radiation produced at this facility, and a working knowledge of the Radiation Safety and Access Control System. They receive appropriate radiological training provided by S&EP. Other Tandem personnel are required to have radiological training from S&EP necessary for their assigned duties.

APPROVALS:


TVDG Safety


TVDG Group Leader

4.1.2) Insulating Gas Handling System

4.1.2.1) Introduction: In any large high voltage equipment, the presence of extremely high potential gradients necessitates the use of an insulating medium for stable operation. For this reason, the high voltage structures of MP6 and MP7 are enclosed within large (11,250 cubic feet) pressure vessels containing a pressurized insulating gas. These vessels are code stamped, meeting the ASME Boiler and Pressure Vessel Code, Section VIII, Division I, with a maximum rated pressure of 300 psig. Overpressure relief valves rated at 250 psig are located on the main fill line and on each vessel. Both MP6 and MP7 use a gas mixture composed of roughly 45% SF₆, 45% N₂, 5% CO₂ and 5% O₂.

As standard facility equipment, HVEC historically supplied a system for transferring gas between the accelerator pressure vessels and a storage facility. Typically, the HVEC system imposed a 20 hour turn around time for transferring gas from an accelerator to the storage facility and back to the accelerator following maintenance. With the need to service two accelerator structures as well as the MP6 terminal ion source, it was felt that the HVEC gas handling system would contribute substantially to machine downtime. This would be particularly true when a simple yet vital repair was needed to resume machine operation. Therefore, the conceptual design of a high speed insulating gas handling system was undertaken by TVDG personnel in consultation with HVEC. Detailed design and installation was performed by the Catalytic Construction Co., the TVDG facility lead contractor.

Figure 4-1 shows a schematic layout of the insulating gas handling system identifying major components.

4.1.2.2) Design Criteria: The underlying design philosophy aimed at creating a system capable of moving large amounts of insulating gas safely and quickly between the accelerator pressure vessels and the insulating gas storage facility. In order

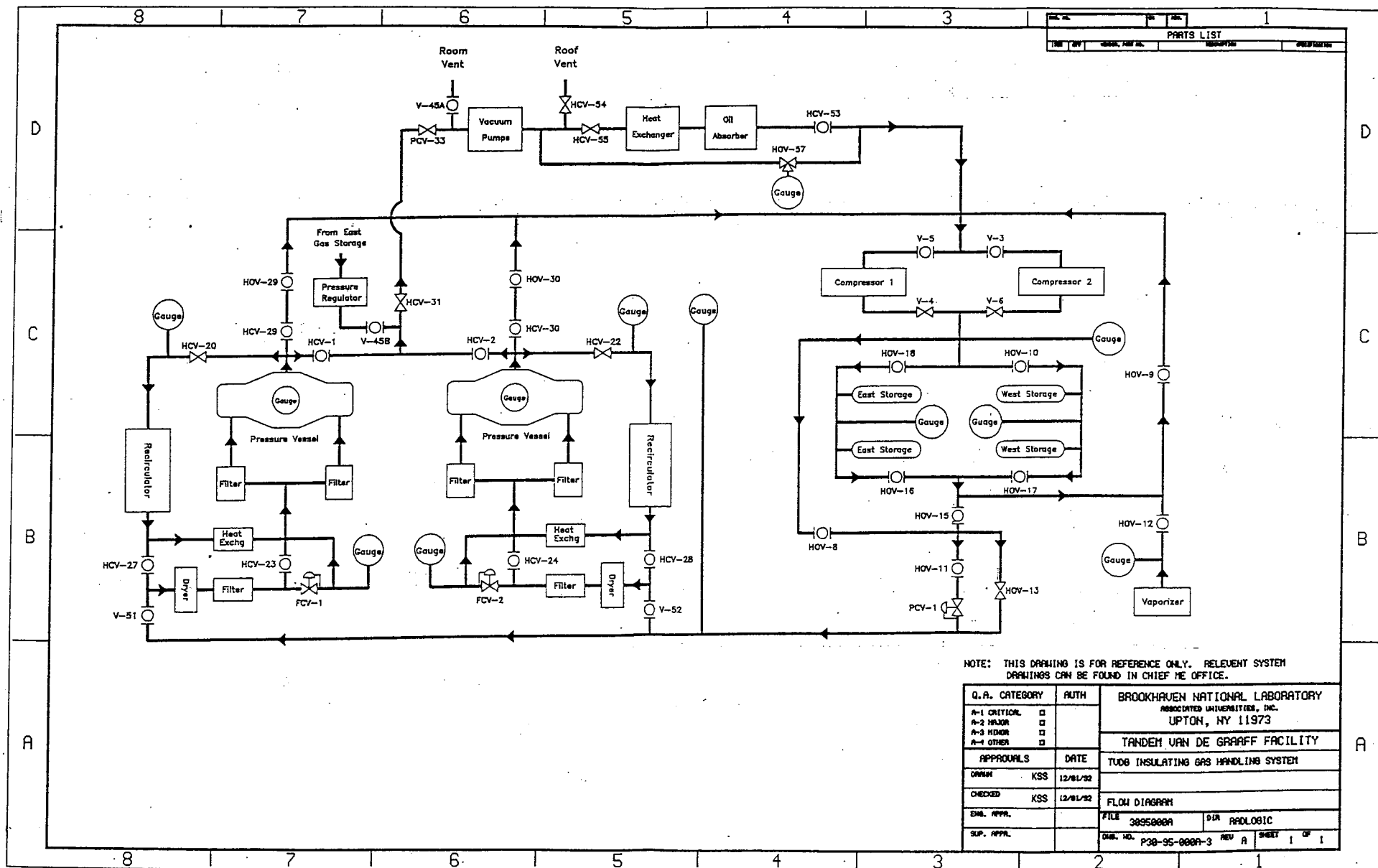


Figure 4-1: Insulating Gas Handling System

to permit opening and closing of an accelerator pressure vessel in a single shift, a goal of four hours was set for completing all phases of gas pumping. Discussions with HVEC determined the limiting design factors to be both the time rate of change of temperature of accelerator structural members, and the maximum allowable temperature gradient along these members.

To avoid temperature shocking the glass and metal accelerator tubes and column structures within the pressure vessels the maximum dT/dt was conservatively chosen to be 10°F/hr, with a maximum gradient along the accelerator structures of 10°F. To this end, one external and four internal heat exchangers provide heating or cooling to the insulating gas as necessary. Automatic temperature controllers are used to modulate hot and cold water flow to these heat exchangers.

Following installation, one accelerator was put through a complete pressure cycle with thermocouples monitoring the internal structures. As it turned out, the low thermal conductivity and high heat capacity of these structures was in itself enough to maintain temperatures within the above specifications. Therefore, although use of the temperature regulating system is standard procedure, it is not an absolute requirement for machine safety.

The two major considerations for personnel safety are the physical hazards associated with a rupture of a system component due to over-pressure, and the oxygen displacement asphyxiation hazard posed by the insulating gas. To minimize these hazards, the gas handling system includes a variety of safety features. These include detailed written procedures for all phases of gas transferral, automatic pressure control and flow control valving at key points, the use of over-pressure relief devices throughout the system, and keyed locks and microswitches to ensure that a vessel is secured prior to pressurization. The Facility has a calibrated test stand for testing of relief valves. The facility periodic maintenance program PERM calls for testing of relief valves every five years. All relief valves throughout the system discharge to their immediate locale.

Automatic isolation ball valves and overpressure relief flanges are located at beamline/accelerator penetrations to halt gas flow in the event of an accelerator tube rupture. The valves actuate upon loss of vacuum in the accelerator tubes. Overpressure relief flanges prevent pressurization of the beamlines while the ball valves are closing.

To alert personnel of an oxygen displacement hazard, fixed oxygen sensing and insulating gas detection equipment constantly monitor ambient conditions. In particular, an SF₆ detection system monitors the gas storage facility and various locations in the Accelerator Rooms with sensitivity adjustable down to 10 ppm. Oxygen monitors on both the main level and the pit level of the Accelerator Rooms and in the Mechanical Equipment Room alarm below 19.5%. Should any unusual levels of oxygen or SF₆ be detected, these systems will alert operations personnel immediately. An operator can then initiate procedures outlined in the TVDG OPM (TVDG OPM Safety Appendix Procedures I,II and III).

If only the SF₆ alarm activates, the situation is likely to be a minor gas leak, a maintenance problem rather than an emergency. After checking to ensure that there is no indication of oxygen deficiency, operators may enter the affected area. As a precaution, they carry portable oxygen and halogen monitors, personnel distress monitors and two way radios while locating and isolating the leak. If only a single oxygen monitor alarms, with no other evidence of a gas leak, it is likely that the monitor is giving a false alarm and requires service. After activating a high speed purge system and notifying the Local Emergency Coordinator, operators may enter the affected area, carrying the same safety equipment as for an SF₆ alarm. In each of the above cases, emergency responses are initiated if portable monitors indicate an oxygen deficiency.

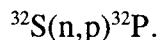
If an oxygen monitor alarms along with one or more of the following:

1. An audible leak is heard
2. A second oxygen monitor alarms
3. An SF₆ monitor alarms

then, the situation is treated as an emergency and Laboratory Emergency Response personnel are notified immediately. The high speed purge is initiated and the Local Emergency Coordinator is notified. During the emergency, the building is evacuated. It is unlikely that individuals outside of the immediate area are at risk of asphyxiation. The building ventilation system does not circulate air from the Accelerator Rooms into the office and laboratory areas. Although there are some connections to lowlying areas of the building via cable tray passageways, under doorways, etc., it is expected that normal building ventilation combined with mixing with room air would prevent concentrations from reaching hazardous levels. The primary purpose of the building evacuation is to ensure that individuals do not enter affected areas and to avoid interference with emergency responders. Further details of all of the above procedures can be found in the TVDG OPM.

In certain applications, it has been shown that SF₆ can decompose in an electric discharge, producing toxic reactive compounds such as S₂F₁₀. We are not aware of any evidence that these compounds have been detected in harmful concentrations in the insulating gas of an accelerator. The activated alumina drying towers through which the insulating gas of the TVDG accelerators constantly circulates should form effective scrubbers for these compounds. Independent toxicity tests of the gas mixture from the TVDG Facility have shown no evidence of toxicity (Appendix VI). During these tests a mouse survived in an atmosphere of 80% tank gas and 20% oxygen for 18 hours with no apparent ill effects.

It is possible for the insulating gas in the accelerator pressure vessels to become activated through the reaction



³²P is a β⁻ emitter with no associated gamma. Its half-life is approximately 14 days. Calculations indicate that under unusual operating conditions (high current, high energy proton or deuteron beams) the quantity of ³²P produced could be sufficient to make the

interior of the gas handling system a contamination area for as long as a few months.

The most extreme operating conditions during the past several years have been for the purpose of shielding effectiveness studies. These studies generally use 26 MeV deuteron beams of maximum intensity over a period of several days. The interior of the tank has been smeared at the first tank opening following these studies, and no activation has been found. The Facility Group Leader and the Operations Supervisors are aware of the possibility of activation and require the interior of the gas handling system to be smeared and checked for β^- contamination during the first opening after such beams are produced.

Any environmental hazard from the activated tank gas would normally be limited to about 1ft³ per day of fugitive emissions. It is expected that the ³²P would settle onto the surfaces of the gas handling system rather than remaining suspended in the gas. Even if it did remain suspended and was released, the release rate would not exceed about 1 nCi per day.

4.1.2.3) Hazard Identification and Mitigation: The Risk Assessment Forms define those hazards for which mitigation was necessary. As defined by the BNL ES&H Standard 1.3.3, the TVDG Insulating Gas Handling System constitutes a low risk system with only extremely remote potential for causing personnel injury, program downtime, and equipment loss or damage.

4.1.2.4) Operational Safety Limits: In accordance with BNL ES&H Standards 1.3.3 and 1.3.4, three operational safety limits, OSL_IGHS_1, OSL_IGHS_2, and OSL_IGHS_3, have been established to ensure safe system operation.

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Insulating Gas Handling System

SUB-SYSTEM: Accelerator Pressure Vessels

HAZARD: Possible toxicity of SF₆ breakdown products.

Hazard impact: Possible loss of life or severe injury of personnel.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors:

- 1) Samples of the insulating gas mixture have been tested for toxicity by an independent lab. The gas showed no evidence of containing any toxic compounds. During these tests a mouse survived in an atmosphere of 80% tank gas and 20% oxygen for 18 hours with no apparent ill effects.
 - 2) At the TVDG Facility, the insulating gas is constantly circulated through activated Alumina drying towers specifically to remove residual water vapor. However, the Alumina is likely to act as an effective scrubber for any toxic decomposition products from the SF₆.
 - 3) We are not aware of any evidence that these toxic compounds have been detected in harmful concentrations in the insulating gas of an accelerator.
-

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVBG Group Leader

June 11, 1995

4-16

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Insulating Gas Handling System

SUB-SYSTEM: All

HAZARD: Asphyxiation due to oxygen displacement by massive escape of insulating gas.

Hazard impact: Possible loss of life of personnel in affected areas and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☒ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: An active area monitoring system constantly analyzes air samples from strategic points in the Accelerator Room, ME Room and Gas Storage Facility. The system is sensitive to SF₆ concentrations as low as 10 ppm and will alert operations personnel should background levels rise above acceptable limits (typically 100 ppm). Fixed oxygen monitors are also located in the pit areas of MP6 and MP7 and will alert personnel in the event of an oxygen deficiency. Emergency exhaust ventilation is provided in the Accelerator Room and the ME Room, allowing approximately one air exchange every 12 minutes. Most probable release scenarios do not involve instantaneous release of all gas, but rather more gradual release with time scale of about half an hour. Under these conditions the oxygen concentration in nearly all of the accelerator room would be sufficient to sustain life. Also, any massive release capable of substantially reducing the oxygen concentration would produce a loud noise.

Emergency Operating Procedures detailing TVDG Operations Staff response to an SF₆ escapement or O₂ deficiency are detailed in the TVDG OPM (TVDG OPM Safety Appendix Procedures I, II and III).

Other safety features include the use of automatic isolation valves at ends of the accelerators in case of an internal accelerator tube rupture, and the presence of metal covers over all accelerator pressure vessel windows to prevent accidental shattering. Manual leak checking is performed during machine pressurization. Joints and seals are inspected annually for signs of wear or leakage as per the TVDG Periodic Maintenance (PERM) List.

The TVDG Maintenance Procedures Manual (MPM) contains gas transfer and pumping procedures.

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:

TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Insulating Gas Handling System

SUB-SYSTEM: MP6 & MP7 Accelerator Pressure Vessels

HAZARD: Rupture of vessel, manway door, viewing window, or accelerator tube.

Hazard impact: Possible severe personnel injury, equipment loss or damage, program downtime, or partial loss of insulating gas inventory.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Pressure vessels are code stamped, meeting the ASME Boiler and Pressure Vessel Code, Section VIII, Division I, and are rated to 300 psig. Prior to installation, the vessels were hydrostatically tested to 450 psig. Over-pressure relief valves set in accordance with ASME standards are installed on both pressure vessels. Manway doors are interlocked to ensure positive closure prior to pressurization. Viewing windows have metal covers to prevent accidental blows to the glass. Automatic isolation ball valves are located at beamline penetrations to halt gas flow in the event of an accelerator tube rupture. Blow off flanges outside the ball valves prevent pressurization of beamline components.

Joints and seals are inspected annually for signs of wear or leakage as per the TVDG Periodic Maintenance (PERM) List.

The TVDG MPM contains gas transfer and pumping procedures.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 12, 1995

4-18

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Insulating Gas Handling System

SUB-SYSTEM: Insulating Gas Storage Facility

HAZARD: Insulating gas escape due to rupture of storage cylinder by over-pressure, temperature stress, or corrosion.

Hazard impact: Program downtime (less than 4 months) and large dollar loss (less than \$1 million) due to loss of insulating gas inventory and damage to storage equipment. More probably, loss would be considerably less because it would not involve all of the gas inventory.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: These storage cylinders were built in 1942 and originally rated at 750 psig working pressure. Independent testing and analysis at the time of acquisition determined that the cylinders would definitely meet ASME Boiler and Pressure Vessel Code, Section VIII, Division I for unfired pressure vessels if the maximum rated working pressure was reduced to 575 psig. The vessels' rating was accordingly downgraded and they were hydrostatically tested to 1.5x the new rating. It was also required to maintain the cylinder temperature above 32°F.

Gas compressor output relief valves are rated at 575 psig. The gas storage facility is monitored by the SF₆ monitoring system and operations personnel are alerted upon detection of SF₆ levels above normal background (typically 100 ppm, but as little as 10 ppm in the leak detecting mode). All joints and seals are inspected annually for signs of wear or leakage as per the TVDG Periodic Maintenance (PERM) List.

Storage cylinders are buried below the frost line maintaining an almost constant temperature of 55°F. Storage cylinders were completely stripped and had a new layer of protective tar and insulating material applied prior to burial.

There are written procedures for gas transfer and pumping.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TV DG Safety


TV DG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Insulating Gas Handling System

SUB-SYSTEM: Other pressure vessels (Dryer and Filter Towers, External Heat Exchangers, Vacuum and Pressure Piping)

HAZARD: Personnel injury due to rupture caused from over-pressure or fatigue.

Hazard impact: Possible severe personnel injury, equipment loss, partial loss of insulating gas inventory, and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Pressure vessels are all ASME Code Stamped and designed to ASME Boiler and Pressure Vessel Code, Section VIII, 1965. All Insulating Gas Handling System pressure and vacuum piping was designed and fabricated in accordance with the ASME Pressure Piping Code (ASME/ANSI B31.3).

Over-pressure relief valves are installed on vessels. Rupture disks prevent accidental pressurization of vacuum piping and equipment. Manual leak checking performed during pressurization. The SF₆ monitoring system detects SF₆ concentrations and alerts the Operations Staff to concentrations above normal background (typically 100 ppm, but as low as 10 ppm in a leak detecting mode), providing early indication of developing leaks.

Joints and seals are inspected annually for signs of wear or leakage as per the TVDG Periodic Maintenance (PERM) List.

The TVDG MPM contains gas transfer and pumping procedures.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_IGHS_1

SYSTEM: Insulating Gas Handling System

SUBSYSTEM: Accelerator Pressure Vessels, MP6 & MP7 Accelerators

PURPOSE OF OPERATIONAL SAFETY LIMIT: To establish safe operating limits which ensure both personnel and equipment safety. Specifically, to ensure that a vessel's safely rated pressure is not exceeded either due to operator error or mechanical malfunction, and to ensure that sufficient barriers are in place to minimize hazards to personnel.

1) SAFETY LIMIT: The absolute maximum allowable working pressure for these vessels is 300 psig, as per ASME Code Stamp on the vessel.

2) DESIGN FEATURES:

A) These vessels are code stamped, meeting the ASME Boiler and Pressure Vessel Code, Section VIII, Division I, with a maximum rated pressure of 300 psig. Vessels were hydrostatically tested to 450 psig prior to installation.

B) A 250 psig pressure relief valve is located on the main insulating gas fill line. A 250 psig pressure relief valve has been installed on each pressure vessel.


3) ADMINISTRATIVE CONTROLS:

A) Only qualified TVDG facility operators are authorized to operate the Insulating Gas Handling System. As part of their training and certification, TVDG operators are required to demonstrate an effective working knowledge and proficiency with the system. Operator qualifications are periodically reviewed by the TVDG supervisory staff.

B) No significant system design feature may be modified without review and approval of the Tandem Safety Committee.

C) Written procedures govern operation of the insulating gas handling system.

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_IGHS_2

SYSTEM: Insulating Gas Handling System

SUBSYSTEM: Insulating Gas Storage Facility

PURPOSE OF OPERATIONAL SAFETY LIMIT: To establish safe operating limits which ensure both personnel and equipment safety. Specifically, to establish safe maximum operating pressure and minimum ambient temperature.

1) SAFETY LIMIT: There are two safety limits for this system:

A) The maximum working pressure for the insulating gas storage tanks is 575 psig.

B) The minimum allowable ambient temperature for the gas storage tank location is 32°F. This is to prevent undue temperature stress on the storage vessels and possible embrittlement of the storage cylinder steel.

2) DESIGN FEATURES:

A) Pressure relief valves at the gas compressor outlet are rated at 585 psig. Pressure relief valves on the manifold for each bank of the Gas Storage Facility are rated at 575 psig. This is not contradictory. The higher pressure relief on the compressor outlet is necessary to allow sufficient pressure to maintain a reasonable flow rate at high storage pressures.

B) The insulating gas storage tanks are covered by earth and lie below the frost line.

C) The Insulating Gas Storage Facility is normally unoccupied and is a completely separate structure from the 901A main building, being located atop the hill behind 901A.

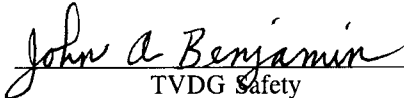
3) ADMINISTRATIVE CONTROLS:

A) Only qualified TVDG facility operators are authorized to operate the Insulating Gas Handling System. As part of their training and certification, TVDG operators are required to demonstrate an effective working knowledge and proficiency with the system. Operator qualifications are periodically reviewed by the TVDG supervisory staff.

B) No significant system design feature may be modified without review and approval of the Tandem Safety Committee.

C) Written procedures govern operation of the insulating gas handling system.

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

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TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_IGHS_3

SYSTEM: Insulating Gas Handling System

SUBSYSTEM: Other Pressure Vessels (Dryer and Filter Towers, External Heat Exchangers)

PURPOSE OF OPERATIONAL SAFETY LIMIT: To establish safe operating limits for these vessels which ensure both personnel and equipment safety. Specifically to establish a safe maximum operating pressure for these vessels.

1) SAFETY LIMIT: The maximum working pressures for these vessels are as follows:

Heat Exchangers:	250 psig @ 300°F
Dryer Towers:	250 psig @ 450°F, 450 psig @ 250°F
Filter Towers:	250 psig @ 100°F

2) DESIGN FEATURES:

A) These pressure vessels are rated for a maximum pressure of 250 psig. A 250 psig pressure relief valve is located on the main insulating gas fill line.

3) ADMINISTRATIVE CONTROLS:

A) Only qualified TVDG facility operators are authorized to operate the Insulating Gas Handling System. As part of their training and certification, TVDG operators are required to demonstrate an effective working knowledge and proficiency with the system. Operator qualifications are periodically reviewed by the TVDG supervisory staff.

B) No significant system design feature may be modified without review and approval of the Tandem Safety Committee.

C) Written procedures govern operation of the insulating gas handling system.

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_IGHS_4

SYSTEM: Insulating Gas Handling System

SUBSYSTEM: All.

PURPOSE OF OPERATIONAL SAFETY LIMIT: To prevent the release of large quantities of insulating gas and to ensure appropriate responses if a release should occur.

1) SAFETY LIMIT: Oxygen monitors alarm for oxygen levels below 19.5%.

2) DESIGN FEATURES:

A) An oxygen monitoring system shall be used to alert building inhabitants to dangerous releases of insulating gas.

B) Manway doors have interlocking devices to preclude pressurization of an accelerator vessel which has not been secured.

3) ADMINISTRATIVE CONTROLS:

A) Written emergency procedures shall detail responses to the release of large quantities of insulating gas.

B) It is the responsibility of the Operations Supervisor to ensure that the insulating gas handling system and the oxygen monitoring system are appropriately maintained and inspected. The insulating gas handling system is leak checked annually. The response of the oxygen monitors is checked monthly.

C) No significant system design feature may be modified without review and approval of the Tandem Safety Committee.

APPROVALS:


TVDG Safety


TVBG Group Leader

June 11, 1995

4-25

4.1.3) Fire Detection and Suppression Systems

4.1.3.1) General Description: The fire detection and suppression systems at the TVDG Facility vary from area to area depending on such factors as combustible loading, normal personnel occupancy, and equipment concentration levels. Fire detection systems include rate of rise detectors, smoke and product of combustion (POC) detectors, and fixed temperature detectors. The system's level of response to these sensors also varies but always includes activation of local alarms and automatic notification of the BNL Fire & Rescue Group via a central control and annunciator panel located in the Building 901A lobby. Fire suppression systems include multipurpose fire extinguishers, automatic Halon systems, and wet sprinklers.

A standpipe system is also provided. Water is brought into the building in the BE Room via a 6" pipe and then distributed via 3" pipe to the east, west, and central portions of Building 901A. At the center of the building, a single valved standpipe connection is provided on each floor level (Main Hall, EE Room, and BE Room), being fed from 1½" pipes which branch off the local 3" pipe. Single valved standpipe connections are also located at the east and west ends of the BE Room, and the east end of the building main hallway (in Lab 3), each fed from 1½" pipes. A 2½" pipe also connects the main 6" feed to a siamese connection located outside the Building 901A main entrance. This allows the BNL Fire/Rescue Group pumper truck to augment the water flow in the system.

The automatic sprinkler system is provided only in the BE Room as this is the

only area of 901A where storage of significant quantities of combustible materials is permitted. The wetpipe sprinkler system is fed separately from the building standpipe system via a 6" pipe entering the BE Room at the west end. The system design complies with NFPA 13 for ordinary hazard occupancies. The sprinkler water control valve is monitored by a tamper switch. Upon activation of a sprinkler head, water flow is sensed automatically and an alarm transmitted to the BNL Fire/Rescue Group via the main annunciator panel in the 901A lobby. The alarm system complies with NFPA 72 for a style 7D system. Combustible storage in the BE Room is limited to cardboard boxes, wood, etc. Combustible polystyrene ductwork also contributes to the fire loading. Storage of significant quantities of flammable liquids or chemicals is permitted only in certain properly identified cabinets in designated areas of 901A.

The Halon Fire Protection Systems provide fire suppression for the TVDG Control Room and the EE Room. These two areas present the most serious potential for dollar and program losses by virtue of the concentration of electrical equipment and cabling. Two separate Halon banks are used, one for each room. Activation and discharge of the Halon occurs in response to tripping of a fixed temperature heat sensor or a local pull box station. Operations staff can exercise an over-ride of the system and should a fire occur, activate the discharge manually using their own discretion. Placing the Halon system under manual control does not prevent any alarm from being automatically transmitted to the BNL Fire Group.

4.1.3.2) Safety Analysis: S&EP has performed several analyses to help ensure TVDG compliance with BNL ES&H Standards on "Fire Protection", (Section

4). Appendix II contains an analysis of compliance with the Life Safety Code (NFPA No. 101) dealing with the ability of building occupants to exit safely during a fire. Compliance with NFPA 101 is required under DOE Order 5480.7. Appendix III contains a Fire Protection Assessment and Fire Hazard Analysis, evaluating Building 901-A compliance with BNL and DOE fire protection standards.

4.1.3.3) Hazard Identification and Mitigation: The Risk Assessment Forms define fire hazards for the various TVDG systems and the factors mitigating these hazards.

4.1.3.4) Operational Safety Limits: There are no Operational Safety Limits defined for this section.

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Accelerators, NIIs, Beam Transport, and Vacuum Systems

HAZARD: Fire

Hazard impact: Moderate dollar loss of equipment and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: It is impossible for a fire to occur within an accelerator pressure vessel during operation as the insulating gas mixture will not support combustion. The most likely cause of a fire involving other equipment in the Accelerator Rooms would be an electrical malfunction. Several factors contribute to minimizing such a hazard.

1) The Accelerator Rooms are equipped with POC, smoke, and rate of rise detectors. Upon activation, these will actuate local alarms and automatically transmit the alarm to the BNL Fire and Rescue Group. Local fire alarm pull boxes and extinguishers are available at numerous points throughout the Accelerator Rooms.

2) As part of their training and certification, Operators are required to become familiar with the Building 901A Fire Protection System and with Emergency Response Procedures in the TVDG OPM (TVDG OPM Safety Appendix Procedure VII) and the document "Emergency Plan - Tandem Van de Graaff - Building 901A".

3) Smoke from a fire can quickly be minimized by activating the purge function of the air handling system for the Accelerator Room involved.

4) Storage of significant quantities of combustible material is not permitted in the Accelerator Rooms.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: TVDG Control Room Systems

SUB-SYSTEM: All

HAZARD: Fire

Hazard impact: Equipment loss and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The most likely cause of a fire involving equipment in the Control Room is an electrical malfunction. A number of steps have been implemented to minimize fire threat to equipment:

1) Fire detection systems include smoke and POC detectors, as well as rate of rise and fixed temperature heat sensors. Fire pull box stations are located both within and just outside the Control Room. Activation of any fire detection sensor automatically transmits an alarm to the BNL Fire and Rescue Group and sounds local alarms. Dry type A,B,C fire extinguishers are located within and just outside the Control Room.

2) As part of their training and certification, Operators are required to become familiar with the Building 901A Fire Protection System and with Emergency Response Procedures in the document "Emergency Plan - Tandem Van de Graaff - Building 901A".

3) A Halon System has been installed with nozzles located throughout the ceiling and under the floor. An "Abort / Normal" switch determines whether the system acts automatically or manually. The system is engaged if either a pull box station is actuated or a fixed temperature heat detector is tripped, and the system is on normal. The TVDG OPM (TVDG OPM Operations Appendix Procedure XVIII) requires that the system be set on normal when the facility is unoccupied. In the event of a power loss, the system can always be engaged manually at a station located in the northwest corner of the Control Room.

To aid in retention of Halon within the room a number of other responses automatically occur when the Halon is released. The Control Room elevator door, the Control Room main door, and the sliding door to the Accelerator Room will automatically close. Also, the air handler (AC-3) will shut down.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Target Room Experimental Equipment

SUB-SYSTEM: Beam Transport and Experimenter Electronics

HAZARD: Fire

Hazard impact: Possible threat to personnel safety, equipment loss and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors:

1) The Target Rooms are equipped with smoke and POC detectors as well as rate of rise sensors. Upon tripping, these will actuate local alarms and automatically cause an alarm to be transmitted to the BNL Fire and Rescue Group. A local fire alarm pull box is located near the shielding door. Dry type A,B,C fire extinguishers are also located within the Target Rooms.

2) As part of their training and certification, Operators are required to become familiar with the Building 901A Fire Protection System and with Emergency Response Procedures. All experimenters receive site specific training about the Tandem Facility, which among other things explains emergency procedures and points out the locations of the pull box stations, fire extinguishers, purge control, and emergency exits.

3) Fire loading is minimal. Storage of significant quantities of combustibles is not permitted. Beam transport equipment (quadrupole and steerer magnets) are spaced along the beam lines, so there is little chance of fire in one piece of equipment propagating to another. The only concentrations of electronics are located at experimenter stations, and are only active when experimenters are present.

4) Smoke from a fire can quickly be minimized by activating the purge function of the Target Room air handler. This action isolates the unaffected Target Rooms and engages a high speed purge fan to clear the affected Target Room.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☒ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Mechanical Equipment (ME) Room Systems

SUB-SYSTEM: All

HAZARD: Fire

Hazard impact: Equipment loss and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The ME Room Systems present little potential for fire hazards. Much of the equipment in the machining area contains motors which in the event of an electrical malfunction could cause a small fire. The gas compressor motors also present a similar hazard.

Non-Flammable Compressed gasses are stored in the ME Room. All flammable compressed gasses are stored outside at the building loading dock.

A soldering bench is located in the ME Room. This is approved by the BNL Fire Group and is not used for cutting and burning. A portable Oxy/Acetylene burning rig is also stored here, and is only approved for use by qualified welders. A job specific permit must be obtained from the BNL Fire Group before this equipment can be used.

The ME Room is equipped with rate of rise sensors which upon tripping will sound local alarms and cause automatic notification of the BNL Fire and Rescue Group. Dry type A,B,C fire extinguishers are provided at several locations throughout the room.

Smoke from a fire can quickly be minimized by activating the purge function of the air handling system for the ME Room.

Storage of general combustibles (wood, cardboard boxes, etc.) is not permitted. Small quantities of flammable liquids can be stored in a properly identified cabinet.

As part of their training and certification, Operators are required to become familiar with the Building 901A Fire Protection System and with Emergency Response Procedures.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Electrical Equipment (EE) Room Systems

SUB-SYSTEM: Beam Transport Power Supplies, Electrical Distribution Centers

HAZARD: Fire

Hazard impact: Equipment loss and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The most likely cause of a fire in the EE Room would be an electrical malfunction in a power supply or Motor Control Center. A number of factors help to mitigate this hazard.

- 1) Fire detection systems include POC detectors and fixed temperature heat detectors. Fire pull box stations are located within and outside the EE Room. Dry type A,B,C fire extinguishers are located within and outside the EE Room.
- 2) A Halon system has been installed. The system will discharge in response to tripping of a fixed temperature heat sensor or manual pull box.
- 3) Activation of any fire detection sensor automatically sounds local alarms and transmits an alarm to the BNL Fire and Rescue Group.
- 4) As part of their training and certification, Operators are required to become familiar with the Building 901A Fire Protection System and with Emergency Response Procedures.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Building Equipment (BE) Room Systems

SUB-SYSTEM: All

HAZARD: Fire

Hazard impact: Equipment loss and program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The most likely cause of a fire in the BE Room would be an electrical malfunction involving a building power distribution transformer of a Motor Control Center. Several factors help to mitigate this hazard.

- 1) Significant quantities of combustibles are stored in this room. However, an automatic sprinkler system has been installed to provide protection against fire. Activation of this system will automatically transmit an alarm to the BNL Fire and Rescue Group.
- 2) Fire pull box stations are located within and outside the BE Room. Activation will sound local alarms and automatically transmit the alarm to the BNL Fire and Rescue Group. Dry type A, B, C fire extinguishers are located within and outside the BE Room.
- 3) As part of their training and certification, TVDG Operators are required to become familiar with the Building 901A Fire Protection System and with the Emergency Response Plan.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: All Occupied Areas of Building 901A

SUB-SYSTEM: N/A

HAZARD: Fire

Hazard impact: Possible threat to personnel safety, moderate dollar loss of equipment.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Fire detection systems in office and lab areas are limited to rate of rise sensors. These will automatically sound local alarms and transmit and alarm to the BNL Fire and Rescue Group. Fire detection and protection systems in other areas have already been described in Risk Assessments covering equipment loss and programmatic delay. Dry type A,B,C fire extinguishers are located at various locations. Fire alarm pull box stations are located generally next to fire extinguishers. Upon activation, these will sound local alarms and transmit an alarm to the BNL Fire and Rescue Group.

Considering the level of building occupancy, it is extremely unlikely that a fire could develop unnoticed long enough to present a serious threat to occupants.

Some labs do contain flammable chemical or liquid storage. However, this is limited to small quantities and properly identified storage cabinets are provided.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☒ 4 (Routine Risk)

APPROVALS:


TVDS Safety


TVDS Group Leader

4.2) Specific Systems by Location

4.2.1) Accelerator Rooms

4.2.1.1) Introduction: As originally delivered by High Voltage Engineering Corp., the MP6 & MP7 accelerator systems and subsystems were identical in terms of both structures and capabilities. Although numerous modifications have vastly improved the performance capabilities of both accelerators, the major safety considerations have remained for the most part unchanged. Thus, this SAD addresses safety concerns for the two accelerators systems generically. Possible hazards are noted area by area, with the Risk Assessment Evaluations for these systems following section 4.2.1.4. Situations peculiar to either MP6 or MP7 or their sub-systems are treated on an individual basis as necessary.

4.2.1.2) Equipment: Equipment in the Accelerator Rooms is divided into several major systems. This section will describe the Tandem Accelerators, the Negative Ion Injectors, beam transport equipment, vacuum system, and the 7 ton overhead crane, and identify hazards associated with these systems.

The twin Tandem Accelerators, MP6 & MP7, form the heart of the complex. Originally designed for maximum terminal potentials of 10 MV, extensive modifications have vastly improved machine performance. Terminal potentials on MP7 now routinely run between 14.0 MV and 15.0 MV, with a maximum of 16.0 MV. Possible hazards associated with machine operation include radiation from the $_{55}\text{Cs}^{137}$ source mounted in a shielded pig on the underside of the pressure vessel, beam induced radiation, normal high pressure gas hazards, asphyxiation hazard posed by the insulating gas mixture, and confined space hazards during tank entry for maintenance. Asphyxiation and other hazards related to the insulating gas mixture have been described in section 4.1.2. Other hazards are described in the risk assessments at the end of this section.

The negative ion injectors consist of the ion sources, beam transport elements,

and power supplies needed to produce and deliver a desired ion specie to a Tandem Accelerator. Power requirements range from 12 kW (300 A at 40 VDC) for the analyzing magnet to less than 200 watts (1.5 A at 120 VAC) for heaters. High voltage DC power includes low stored energy supplies ranging from 10 kV to 300 kV, and high stored energy supplies rated up to 4.8 kW (80 kV at 60 mA). Because high voltages are present, a grounded steel cage encloses the injector area to provide personnel safety. Interlocks and automatic grounding mechanisms ensure that no lethal high voltages are present when the cage door is open. Primary three phase 480 VAC power is delivered to the injector via an isolation transformer located in the pit area beneath the cage.

Beam transport equipment includes numerous dipole and quadrupole magnets, electrostatic steerers and lenses. Power requirements for the magnets range from tens of watts for the small steerer magnets to 40 kW (500 A at 80 VDC) for the TTB 11DH1 and 11DH2 dipoles. Electrostatic elements require relatively low power at high voltages ranging from 3 kV to 50 kV. High voltage power supplies for the electrostatic elements are located in the pit areas. The relatively high (> 10 G) stray magnetic fields produced by the beam transport magnets presents a possible threat to persons with implanted cardiac pacemakers, and so the Accelerator Rooms are posted to indicate this hazard. The high voltage power supplies are located within grounded metal enclosures. High voltage cables are typically type RG-8 or equivalent shielded cables, and high voltage connections are either recessed or shielded. Thus, under normal operating circumstances, these power supplies present no hazard.

The vacuum system consists of a wide variety of pumps and controlling systems required to maintain adequate vacuum conditions in the beamlines, ion sources, and accelerator tubes. Most standard types of vacuum pumps are used, including cryo-pumps, turbo-molecular pumps, ion pumps, oil diffusion pumps, and mechanical displacement roughing pumps. The accelerators and negative ion injectors have dedicated vacuum control modules for control, monitoring and interlocking of the local vacuum sub-system. A number of roll around vacuum carts are available for use where needed. Sub-sections

of the vacuum system are isolated by automatically controlled and interlocked valves which prevent vacuum problems in one area from affecting adjacent areas.

4.2.1.3) Hazard Identification and Mitigation: The Risk Assessment Forms identify those hazards for which mitigation was necessary. As defined by the BNL ES&H Standard 1.3.3, the Accelerator Room systems present a low risk with only extremely remote potential for causing personnel injury, program downtime, and equipment loss or damage.

4.2.1.4) Operational Safety Limits: In accordance with BNL ES&H Standards 1.3.3 and 1.3.4, an operational safety limit has been established to ensure safe system operation. The OSL is OSL_ACCL_1.

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: N/A

HAZARD: Personnel exposure to high radiation fields induced by accelerated beam.

Hazard impact: Acute whole body exposure resulting in a Dose Equivalent or Committed Effective Dose Equivalent of 100 rem on-site.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☒ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: All personnel entering the Accelerator Rooms or Target Rooms are protected against radiation exposure in excess of administrative limits by the TVDG Radiation Safety and Access Control System. This system, fully described in Section 4.1.1, controls access to those areas. All entry points to the Accelerator Rooms other than the entry through the Control Room are kept locked.

The Radiation Safety and Access Control System is designed to be failsafe. It is immune to short term power interruptions, as power is obtained via a motor-generator set. The system is designed such that longer power interruptions will cause the system to revert to a failsafe condition.

As part of their training and certification, TVDG Operators must demonstrate an understanding of the causes and forms of radiation produced at this facility, and a working knowledge of the Radiation Safety and Access Control System. Other Tandem personnel are required to have radiological training necessary for their assigned duties.

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Accelerators, Ion Source and Injector Areas

HAZARD: X-Radiation resulting from fault mode acceleration of electrons.

Hazard impact: Acute whole body exposure resulting in a Dose Equivalent or Committed Effective Dose Equivalent of 100 rem on-site.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☒ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Because it is virtually impossible to eliminate the sources of unwanted electrons in the NIIs and Accelerators, emphasis has been placed on preventing acceleration of these electrons. In the ion sources, permanent magnets deform the electron trajectories, deflecting them off axis and preventing them from being extracted and injected into an accelerator. Electrons produced by ion beam bombardment of a surface near the entrance of the NII pre-accel tube are suppressed by a biased aperture at the entrance to the tube.

In the accelerator tubes, the so called "inclined field" geometry provides a transverse component of electric field which acts to quickly deflect any electrons into nearby accelerating electrodes before they can be substantially accelerated longitudinally. Additional permanent magnets are located at a number of points along the accelerator tubes to augment electron suppression.

The TVDG Radiation Safety System provides the final level of protection. The Gamma monitors respond to both Gamma and X-Radiation similarly, and should X-Ray levels exceed the safe set point for Gamma radiation in a non-secured zone, the affected accelerator is automatically shut down.

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP7 Accelerator

SUB-SYSTEM: Radiation Source $^{55}\text{Cs}^{137}$, 4 Ci

HAZARD: Personnel exposure to radiation field of the source when it is outside of its shielding.
Dose rate could reach 1.33R/hr at 1 meter.

Hazard impact: Acute whole body exposure resulting in a dose equivalent of 25 Rem on-site.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☒ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The $^{55}\text{Cs}^{137}$ source is located in a shielded pig attached to the underside of the accelerator pressure vessel. The source is inserted into the vessel from the pig by use of a linear manipulator. The large dimensions of the closed vessel prevent close approach to the unshielded source except in the pit area. Even in that area, the dose rate is not sufficient to result in a 25 Rem exposure under any credible circumstances. Therefore, the hazard affects only those who enter the accelerator vessel.

To prevent exposure of personnel who open the pressure vessel to work inside, a key interlock scheme is used. In order to open the first of three manway doors to gain entry, the radiation source must first be retracted and its shield locked closed. That key can then be removed from the pig lock and used to unlock the first manway door, allowing access to the pressure vessel. Keys within this door are then used to unlock the remaining manway doors. Because the radiation source key is held captive in the first manway door, the reverse procedure must be followed to close the machine. The manway doors can only be secured in the reverse order of which they were opened, and then the radiation source key can be removed from the lock on the first door, and used to unlock the radiation source. In addition, the TVDG OPM Tank Entry Procedures (TVDG OPM Operations Appendix Procedures XXVI and XXVII) and sign off list requires personnel to verify that the radiation source is retracted and locked, and that a radiation survey of the pressure vessel be performed prior to personnel entry.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-41

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Column Truss Structure

HAZARD: Column failure due to excessive static loading.

Hazard impact: Possible personnel injury, severe equipment damage, and prolonged program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☒ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The designers of the Tandem Accelerators, High Voltage Engineering Corp., have specified maximum additional static loading which can be accommodated by the accelerator column truss system. Referenced to a static load concentrated in the center of the accelerator terminal, the following additional loads can be accommodated:

MP6 : 5000 pounds concentrated at the terminal

MP7 : 3000 pounds concentrated at the terminal

The signature of the TVDG Chief Mechanical Engineer is required in the QA block of all drawings of mechanical equipment to be used in Building 901A. (See TVDG SEAPPM 1.3.5.) In addition, the Operations Supervisor oversees all modifications involving addition or removal of equipment from the accelerators and is responsible for informing the Chief Mechanical Engineer. Therefore, all modifications involving addition or removal of equipment from the accelerators are reviewed by the TVDG Chief Mechanical Engineer.

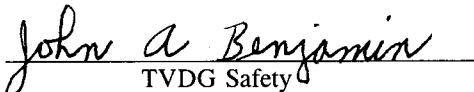
Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-42

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Negative Ion Injectors

HAZARD: Possible contact with high voltage power supplies rated up to 300 kV.

Hazard impact: Possible loss of life or serious personal injury.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☒ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: The negative ion injectors are completely enclosed with a grounded metal cage to prevent personnel access when the high voltage supplies are energized. Access to this cage is through a single door. In order to enter, a person must first remove a key from a local control console which forms part of the high voltage interlock string and thus de-energizes the HV power supplies. A key which is physically attached to the console key must then be used to unlock and open the cage door. This lock is also part of the high voltage interlock string and provides redundant safety. The key is held captive in the lock until the cage door is closed and the locking mechanism is again engaged.

For added safety, a mechanical shorting system is also in place. This system consists of a number of grounded metal bars which drop down and short the major high voltage supplies to ground whenever the door is open. Written procedure requires the entrant to attach an additional grounding strap.

The TVDG OPM (TVDG OPM Operations Procedures Appendix XIII) requires the use of a two man rule whenever anyone is to enter the cage while primary isolation power (480 VAC) is on. Emergency Kill switches are located at various points in and around the NII cage. Upon activation of one of these switches, all power sources within the cage are shut down.

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: All components exposed to accelerated beam.

HAZARD: Beam induced activation of components exposed to accelerated beam.

Hazard impact: Possible release of activated materials into non-controlled areas.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Potentially activated items removed from the vacuum system are surveyed before being released from the area.

All TVDG Operations Personnel receive the required Radiation Worker Training including training in the use of radiation survey equipment.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☒ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-44

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Beam Transport

HAZARD: Personnel contact with high voltages.

Hazard impact: Possible loss of life or severe personal injury.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Generally, all high voltage power supplies include cabling supplied by the manufacturer as well as instructions for proper installation and operation.

Where connections are made to devices, the connection points are either fully enclosed or recessed and shielded to prevent accidental contact. Typically, the actual device being powered is located within the vacuum system or the accelerator pressure vessel, and so does not present an immediate hazard under normal operating conditions. Deviations from normal procedures require written authorization as per BNL ES&H Standard 1.5.0.

The TVDG OPM (TVDG OPM Operations Appendix Procedure XIII) requires personnel to observe all precautions as set forth in BNL ES&H Standard 1.5.0 and 1.5.1, including Lock Out and Tagging of power supplies when either the supplies or associated equipment are to be worked on.

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-45

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: All

HAZARD: Exposure of personnel with implanted cardiac pacemakers to stray static magnetic fields exceeding 1.0 mT (10 Gauss).

Hazard impact: Exposure to static magnetic flux densities in excess of 1.0 mT (10 Gauss) may cause anomalous behavior of implanted cardiac pacemakers. It should also be noted that perceptible adverse affects may be produced at higher flux densities resulting from forces upon other implanted ferromagnetic medical devices (staples, clips, prostheses, etc.).

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Stray magnetic field surveys have been carried out for all magnets at this facility. Typically, stray magnetic fields did exceed the 1.0 mT (10 Gauss) TLV and thus a posting procedure has been implemented at the facility to warn personnel against inadvertent exposure to these fields.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☒ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-46

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: Accelerator Pressure Vessels

HAZARD: As per BNL ES&H Standard 2.2.4, an accelerator pressure vessel constitutes a confined space. Hazards include oxygen deficiency, high voltage equipment, large rotating machinery, and radiation.

Hazard impact: Possible asphyxiation of personnel due to escape of insulating gas into the vessel interior. Possible personnel injury due to contact with high voltage equipment or rotating machinery. Possible radiation exposure of personnel contrary to BNL ES&H Standards 3.1.0 and 3.3.0.

Risk assessment prior to mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☒ 2 (Moderate Risk) ☐ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Personnel entry into an accelerator pressure vessel is subject to the TVDG OPM Tank Entry Procedure generated in compliance with BNL ES&H Standard 2.2.4 and applicable OSHA and ANSI standards. Specific requirements are detailed in the TVDG tank entry procedure found in the TVDG OPM (TVDG OPM Operations Appendix Procedures XXIV and XXV). Included among these requirements are: Double block or disconnection of all gas transfer lines entering the vessel, provisions for purging the vessel prior to personnel entry and for maintaining positive ventilation during occupancy, systems for monitoring the O₂ level in the vessel and for detection of minute quantities of insulating gas, a "Kirk" style key interlocking scheme to ensure that the ⁵⁵Cs¹³⁷ radiation source is retracted and locked closed prior to and during personnel occupancy, and a radiation survey of the vessel prior to entry and constant monitoring of the vessel during occupancy. High voltage and rotating machinery hazards are covered by the TVDG Lock Out / Tag Out Procedure in the TVDG OPM (TVDG OPM Operations Procedures Appendix XII). Instructions for closing the tanks include checking to ensure that no personnel remain inside the tank (TVDG OPM Operations Procedures Appendices XXVI and XXVII).

Risk level following mitigation:

Hazard severity: ☒ I (Catastrophic) ☐ II (Critical) ☐ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: MP6 & MP7 Accelerator Room and Target Room Overhead Cranes

SUB-SYSTEM: N/A

HAZARD: General hazards involved with rigging, lifting and moving of large equipment through use of the overhead crane.

Hazard impact: Possible personnel injury, equipment damage or program downtime.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: Operation of the overhead crane is restricted to TVDG operations personnel holding valid SAC cards and to other authorized personnel (electricians, riggers, etc.) who hold valid SAC cards and are under administrative control of TVDG operations.

Operating procedures are in compliance with BNL ES&H Standard 1.6.0 (Material Handling Equipment).

Primary power to overhead cranes is key locked. Any person needing to operate a crane must receive authorization from TVDG Operations in order to have the power unlocked.

All rigging equipment is inspected on a regular basis by TVDG Operations personnel. Annual inspection of rigging tackle and accessories is controlled by PERM.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☐ D (Remote) ☒ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☐ 3 (Low Risk) ☒ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-48

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_ACCL_1

SYSTEM: MP6 & MP7 Accelerators

SUBSYSTEM: Column Truss Structure

PURPOSE OF OPERATIONAL SAFETY LIMIT: To establish safe operating limits which ensure personnel and equipment safety. Specifically to ensure that the maximum safe additional column load limit is not exceeded.

1) SAFETY LIMIT: The safety limits for MP6 & MP7 are different:

A) For MP6, the maximum additional column load which may be added to the original configuration is 5000 pounds concentrated at the high voltage terminal.

B) For MP7, the maximum additional column load which may be added to the original configuration is 3000 pounds concentrated at the high voltage terminal.

2) DESIGN FEATURES:

A) The designers of the Tandem Accelerators, High Voltage Engineering Corp., have specified the above values as acceptable limits for safe loading of the column truss.

3) ADMINISTRATIVE CONTROLS:

A) Any modifications involving addition or removal of equipment from the accelerators are reviewed by the TVDG Chief Mechanical Engineer.

APPROVALS:


TVDG Safety


TVDG Group Leader

4.2.2) Control Room

4.2.2.1) Equipment: Equipment in the Control Room can be divided into three sections: the original TVDG control console and stand up racks, the newer TTB control console, and the numerous patch panels used to route signals between the Control Room, Target Rooms, and certain areas of the Accelerator Rooms.

The equipment contained within the Tandem control console comprises the bulk of the fixed equipment within the Control Room. The main console houses a wide array controls and monitoring equipment for all MP6 and MP7 Accelerator and beam transport components. This includes the controls for accelerator charging system and other components within the accelerator pressure vessels, controls for beam steerers, focussers, and bending magnets, electrometers for measuring beam currents, and NMR flux meters for measuring fields within the main analyzing and selecting magnets.

The newer TTB control console contains control and monitoring equipment for the TTB beam transport line. TTB functions are controlled through a single Apollo computer node via the AGS Distributed Control System.

4.2.2.2) Hazard Identification and Mitigation: Other than possible fire, the TVDG Control Room systems present no hazard or threat to personnel welfare. Fire safety system descriptions and risk assessments are found in section 4.1.3.

4.2.2.3) Operational Safety Limits: There are no operational safety limits defined for this section.

4.2.3) Target Rooms:

4.2.3.1) Equipment: Fixed equipment in the Target Rooms is limited to the beam lines, beam transport equipment (magnetic box steerers and quadrupoles) and vacuum systems. Operation of this equipment is simply an extension of similar Accelerator Room systems. Power requirements for the Target Room magnets are less than for the Accelerator Room magnets, with the largest power supply rated at 2 kW (40 VDC, 50 A)

for the quadrupoles.

Equipment at user stations varies with usage. The Operations Supervisor performs a safety review of new experiments, tests or irradiations before they may commence. This review is based on a safety checklist which has been approved by the Tandem Safety Committee and the TVDG Group Leader. Any new experiment, test or irradiation with unusual safety concerns identified by the checklist must be approved by the Tandem Safety Committee.

TR3 is not at present an active Target Room. Part of the room houses the power supplies and control system equipment for the first third of the HITL beamline. The remainder of the room is currently allocated to another group for projects unrelated to the Tandem accelerators.

4.2.3.2) Hazard Identification and Mitigation: Threats to personnel welfare in the Target Rooms include fire, radiation, mechanical and electrical hazards. Fire safety system descriptions and risk assessments are found in section 4.1.3. The TVDG Radiation Safety and Access Control System is described in section 4.1.1.

4.2.3.3) Operational Safety Limits: There are no operational safety limits defined for this section.

4.2.4) Mechanical Equipment Room:

4.2.4.1) Introduction: The Mechanical Equipment Room contains a wide assortment of equipment related to accelerator and building support functions. Major equipment includes accelerator gas handling equipment, a number of small machine tools, a deionized water supply system, a soldering bench, LN₂ storage dewars, and motor control centers.

4.2.4.2) Equipment: A description of all ME Room equipment is found in section 2.4.5. This section describes only equipment which poses some hazard to personnel.

Pressure and asphyxiation hazards involving the insulating gas handling equipment are treated in section 4.1.2. The main physical hazards are from the large (6' diameter) flywheel on each Norwalk compressor, and the drive motors and belts on the compressors and the vacuum pumps. To minimize any risk, the compressor drive pulley, belts, flywheels have been enclosed with steel cages, and the drive pulleys and belts on the vacuum pumps have been enclosed by Lucite panels. The room has also been posted as a high noise area with a requirement for hearing protection when the pumps are operating.

Hazards related to the machine shop are those normally associated with operation of any machine tool. Every tool is grounded and is posted with the requirement that eye protection be worn while operating. The machine shop is under the administrative control of the TVDG Operations Group, with most tools padlocked to prevent access by unauthorized persons. The need for point of operation guarding has been reviewed by the Facility Chief Mechanical Engineer and necessary guards have been installed. Users of these machine tools receive training from qualified TVDG personnel.

Under normal operating conditions, the Deionized Water System poses no hazard. In the past, reactivation of the system involved the use of caustic liquids and produced waste water which contained traces of heavy metals beyond the allowed limits for discharge to sanitary waste systems. In the future, it is planned that the resin beds will be replaced and disposed of as hazardous waste rather than being reactivated or that a suitable means will be found to collect and dispose of the wastewater.

Fire hazards involving the ME Room systems are treated in section 4.1.3. It should be noted that there is a small storage cabinet for flammable liquids located in ME Room.

Non-Flammable compressed gasses are stored in the ME Room. Flammable compressed gasses are stored outside on the Building 901A loading dock.

4.2.4.3) Hazard Identification and Mitigation: A Risk Assessment Form identifies the only hazard requiring mitigation. As defined by the BNL ES&H Standard 1.3.3, the ME Room systems present a low risk with only extremely remote potential for causing personnel injury, program downtime, equipment loss or damage.

4.2.4.4) Operational Safety Limits: There are no Operational Safety Limits defined for this section other than those relating to the insulating gas handling system. Those limits followed the description of that system in Section 4.1.2.

4.2.5) Electrical Equipment Room:

4.2.5.1) Introduction: The Electrical Equipment Room serves a variety of purposes. A description of the equipment and offices located here is found in section 2.4.7. This section describes the hazards posed by the high current magnet power supplies located in the room. Fire safety considerations are treated in section 4.1.3.

4.2.5.2) Equipment: Located in two rows of stand up racks are the power supplies for the dipoles, quadrupoles, and steerer magnets in the Accelerator and Target Rooms. The dipole and quadrupole power supplies are fairly large high current DC supplies using 480 VAC for primary power. These power supplies also contain large, high stored energy capacitor filter banks. As such, the access doors for these power supplies are interlocked with microswitches which cause the main power contactors to disconnect if an access door is opened.

4.2.5.3) Hazard Identification and Mitigation: Other than possible fire, the TVDG EE Room systems present no hazard or threat to personnel welfare. Fire safety system descriptions and risk assessments are found in section 4.1.3.

4.2.5.4) Operational Safety Limits: There are no Operational Safety Limits defined for this section.

4.2.6) Building Equipment Room:

4.2.6.1) Introduction: The Building Equipment Room serves as a central location for building HVAC equipment, air compressors, and electrical distribution transformers and panels. It is also the only area of Building 901A where storage of

significant quantities of combustibles is permitted. A description of the equipment located here is found in section 2.4.6.

4.2.6.2) Hazard Identification and Mitigation: Other than possible fire, the TVDG BE Room systems present no hazard or threat to personnel welfare. Fire safety system descriptions and risk assessments are found in section 4.1.3.

4.2.6.3) Operational Safety Limits: There are no Operational Safety Limits defined for this section.

4.2.7) Offices and Labs:

4.2.7.1) General: Other than possible fire hazards treated in section 4.1.3, the Building 901A offices present no threat to personnel welfare.

The Ion Source Lab, Lab 1, and Lab 2 contain chemicals and compounds used for development purposes. A storage cabinet for chemicals (elemental and compound) is located in the 901A main hallway just east of the ME Room door.

4.2.7.2) Hazard Identification and Mitigation: Other than possible fire, there are no hazards requiring mitigation. The Fire Safety System is treated in Section 4.1.3. There are no extraordinary chemical hazards. As defined by the BNL ES&H Standard 1.3.3, the 901A Labs present a routine risk with only extremely remote potential for causing personnel injury, equipment loss or damage.

4.2.7.3) Operational Safety Limits: There are no operational safety limits defined for this section.

TANDEM VAN de GRAAFF SAD RISK ASSESSMENT

SYSTEM: Building 901A Labs

SUB-SYSTEM: N/A

HAZARD: A wide variety of chemicals and compounds are stored and used in the labs. Some chemicals are highly reactive or flammable and can present a hazard due to improper use, storage or disposal.

Hazard impact: Possible personnel injury due to chemical explosion, burning, etc. Possible environmental impact due to improper disposal of hazardous compounds.

Risk assessment prior to mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☒ C (Occasional) ☐ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

Mitigating factors: All Operations personnel receive hazard communication training, an up to date list of all chemicals in the labs is maintained, and MSDSs for all commonly used compounds are compiled in a binder available to all personnel. Labs 1 and 2 and the Ion Source Lab have exhaust hoods used when working with hazardous chemicals or compounds. A local Building 901/901A S&EP Technician is available to answer any questions regarding the proper use, storage, and disposal of chemicals.

Risk level following mitigation:

Hazard severity: ☐ I (Catastrophic) ☐ II (Critical) ☒ III (Marginal) ☐ IV (Negligible)

Probability: ☐ A (Frequent) ☐ B (Probable) ☐ C (Occasional) ☒ D (Remote) ☐ E (Extr. remote) ☐ F (Impossible)

Risk Category: ☐ 1 (High Risk) ☐ 2 (Moderate Risk) ☒ 3 (Low Risk) ☐ 4 (Routine Risk)

APPROVALS:


TVDG Safety


TVDG Group Leader

June 11, 1995

4-55

4.2.8) Insulating Gas Storage Facility:

Other than the asphyxiation and pressure hazards treated in section 4.1.2, the Insulating Gas Storage Facility poses no threat to personnel welfare.

4.3) Environmental Considerations of TVDG Operations:

Environmental issues considered in this section include liquid and airborne effluent emissions and generation and disposal of hazardous wastes.

4.3.1) Liquid Effluents: The TVDG has completed the BNL Liquid Effluent Questionnaire which is intended to characterize waste effluents generated by Facility maintained equipment and operations. Liquid effluents released include small quantities of chemicals for which discharge to the sanitary system is allowed (dilute acids, ethanol, etc.), rinse water from the machine shop, which might include small quantities of oil and commonly used metals such as aluminum and steel, and cooling water for pumps and laboratory equipment. Cooling water associated with the accelerator is from a closed loop system. No liquid effluents requiring permits have been identified.

The following concerns about liquid effluents that might be generated by the Facility have been addressed:

1. The effluent that was generated by reactivation of the deionized water system was found to contain heavy metals in concentrations beyond allowed limits for discharge to the sanitary system. It is planned that in the future the resin beds will be replaced and disposed of as hazardous waste rather than being reactivated. If reactivation is resumed, the effluent will be collected and treated or disposed of as hazardous waste.
2. The Building Manager and Operations Supervisors are aware of the possibility that the water in the closed loop deionized water system might become slightly activated during high energy proton and deuteron runs. The water in the

system has been sampled when some discharge was necessary for maintenance. The metal concentration was found to be within allowed limits for discharge to the sanitary system. The water was not found to be activated. Therefore, it may be assumed that any activation, if present, is shortlived. If discharge of deionized water is to be performed at a time when the water might have been activated by recent running conditions, the water will be tested for activation before discharge.

4.3.2) Airborne Effluents: The TVDG has completed the BNL Air Emissions Survey intended to identify all sources of radiological and non-radiological airborne releases which may potentially require air permits. Copies are available through the TVDG ES&H Coordinator. Emission sources included small quantities of compressed gases, spray cans, exhaust from vacuum pumps, a blueprint machine, small scale soldering, machine shop and solvent use. The following concerns have been addressed:

A) An application was filed to allow surface coating in the exhaust hood in Lab 2. Surface coating is limited to spray painting of small items. S&EP has determined that no permit is required for current levels of use (fewer than ten 12 oz. cans of paint per year).

B) Calculations of air activation by TVDG beams are included as Appendix VII.

C) The Insulating Gas Handling System is a closed loop system containing a mixture of SF₆, N₂, CO₂ and O₂. There are 220,000 ft³ of the mixture, and 26,000 ft³ of pure SF₆ in storage. Fugitive emissions total approximately 300 ft³ of SF₆ per year. Samples of the insulating gas have passed toxicity tests performed by Scientific Associates, St. Louis, MO. Results of these tests are found in Appendix VI. Although precautions have been taken to prevent any substantial release of insulating gas (See Section 4.1.2.), large quantities of SF₆ could be released in the event of an accident. The Emergency Planning Group is aware of the possibility of a release and

has been consulted about appropriate responses. The insulating gas has been reported as part of the Non-Radiological Hazardous Materials Inventory for Building 901A and the environmental effects of a release will be evaluated by S&EP at a time determined by a priority assigned as a result of that inventory. The MIRAN monitoring system used to provide early detection of an insulating gas escapement is discussed in Section 4.1.2.

4.3.3) Hazardous Wastes: The TVDG Facility generates small quantities of hazardous chemical wastes, typically solvents, acids, paint and adhesives. These wastes are stored in a 90 day accumulation area located in the Ion Source Lab. Waste oil is stored in the ME Room. Samples are assayed to determine whether waste oil from the pumps used to evacuate the accelerator vacuum system might contain extremely low levels of added radioactivity that would require them to be classified as mixed waste. To date, samples assayed have not been found to contain added radioactivity.

An effort has been made to identify all equipment in the Facility containing PCBs. Sampling of oil in accelerator room transformers showed these to be PCB free (<20ppm). A room by room search conducted in December, 1992 identified two power supplies containing large PCB capacitors and other equipment containing small PCB capacitors.

The Operations Supervisor is responsible for any inventorying, inspecting and labeling required for equipment containing PCBs. Spare equipment containing large PCB capacitors is maintained in posted storage areas.

In order to prevent improper disposal of PCBs, all electrical/electronic equipment is required to undergo a PCB check prior to disposal or surplussing. The Facility ES&H Coordinator is responsible for arranging proper disposal of PCBs.

Beam line components which have been activated by TVDG beams and which are no longer useful can be disposed of as radioactive waste. Typically, this is limited to a few small items per year.

5) Normal and Emergency Operating Procedures

In accordance with DOE Order 5480.19, "Conduct of Operations Requirements for DOE Facilities", the TVDG Supervisory Staff has developed an Operations Procedures Manual and a Maintenance Procedures Manual. The purpose of these manuals is to provide specific direction for operating systems and equipment during normal and postulated abnormal and emergency conditions and for maintenance procedures. Additional information about Facility policy and procedures relating to the OPM can be found in "Tandem Van de Graaff Conduct of Operations Conformance Matrix".

5.1) Procedure Approval and Review: All operating and maintenance procedures are reviewed and approved by the Operations Supervisor prior to issuance. Approval is indicated by inclusion of the procedure in the controlled copy of the OPM or MPM. Emergency procedures and procedures involving safety related equipment or systems are reviewed by the Tandem Safety Committee and are tracked in meeting minutes. Annual review of emergency procedures by the committee is triggered by PERM. In addition, a biennial review of all procedures by the Operations Supervisor is triggered by PERM to ensure that information contained within remains accurate and relevant. New procedures and procedures under review receive a "walk through" to ensure their accuracy and workability.

5.2) Procedure Availability and Use: Single controlled copies of the TVDG OPM and MPM are maintained in the TVDG Control Room. They may be modified only

with the permission of the Operations Supervisor. Operators are required to use checklists contained in the OPM and MPM whenever they are applicable. Other written procedures are considered to be guides that may be consulted by the operators as necessary.

6) Training and Certification

6.1) Accelerator Operators: In order to ensure that all facility operators are fully qualified in all aspects of TVDG Operations, the Operations Supervisory Staff has implemented an On-Shift Training Program. The goal of this program is to maintain the performance level of all qualified operators and to ensure proper training and supervision of "Operators in Training" (non fully qualified operators). The TVDG Operations Supervisor maintains documentation of all operator certification levels.

6.1.1) Qualified Operators: To become certified as a TVDG Facility Operator, an Operator in Training must satisfy minimum skill requirements developed by the Operations Supervisor. This ensures that an operator has demonstrated the level of proficiency required to act as the primary shift operator. The specific requirements are found in the document "TANDEM OPERATIONS, Minimum Skill Requirements". Each year the document is filled out by the Operations Supervisor and discussed with the Operator as part of Performance Appraisal.

6.1.2) Operators in Training: An Operator in Training is any operator who has not satisfied all the requirements to become a fully qualified operator. Instruction is normally delivered by a qualified operator at the direction the Operations Supervisor. Trainees typically are limited to working normal day shifts when the maximum number of qualified staff is available. However, after a trainee has advanced sufficiently, he may be permitted to work any shift under the supervision of a qualified operator.

6.1.3) Review of Operator Qualifications: A review of each operator's qualifications is performed annually as part of the standard BNL Performance Appraisal.

6.2) All Facility Personnel: All TVDG Personnel receive safety orientation and training commensurate with their position. As necessary, training may include the following topics: Radiation Worker, Radioactive Material Control, HAZCOM, CPR, Lockout/Tagout, Forklift/Crane, and Facility Specific Training. Records of Facility Specific Training are maintained by the TVDG Supervisory Staff. All other training records are maintained by the Physics Department Training Coordinator.

6.3) Facility Users: All outside users of the TVDG Facility receive a User Safety Briefing from a TVDG Operator. This briefing is used to acquaint the user with Emergency, Safety and Other Systems specific to the Target Room in which the user will be working, and with the Building and Site Emergency Signals and Evacuation Procedures.

Outside users also receive a Film Badge and instruction from TVDG Operators who have been trained in issuance of Film Badges. Instruction includes the standard BNL "TEMPORARY AND VISITORS FILM BADGE WEARER'S INSTRUCTIONS" and a description of the TVDG Radiation Safety and Access Control System.

TANDEM VAN de GRAAFF SAD

OPERATIONAL SAFETY LIMIT

TRACKING NUMBER: OSL_OPS_1

SYSTEM: MP6 & MP7 Accelerators

SUB-SYSTEM: All

PURPOSE OF OPERATIONAL SAFETY LIMIT: To restrict the operation of the Tandem accelerators to sufficient qualified personnel.

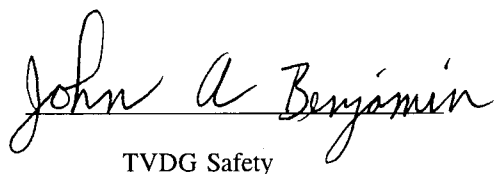
1) SAFETY LIMIT: Two qualified individuals are required for operation of the accelerator.

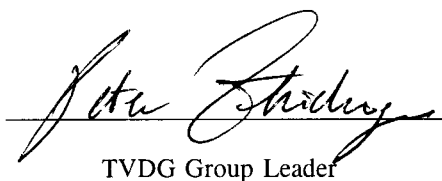
2) DESIGN FEATURES: None.

3) ADMINISTRATIVE CONTROLS: The Tandem Group Leader and Operations Supervisor, or in their absence the Operations Shift Supervisor, shall not permit operation of the Tandem Accelerators unless two operators are on duty. The operator-in-charge must

be fully qualified. The Operations Supervisor maintains a list of individuals who are qualified to act as backup operator. This list includes all fully qualified operators, those operators in training approved by the Operations Supervisor, and other members of the Operations and Development Group who are judged by the Operations Supervisor to have sufficient knowledge of the accelerator to provide competent assistance.

APPROVALS:


TVDG Safety


TVDG Group Leader

7) Experimental Program Safety Review

Experiments, activities and equipment in Building 901A are evaluated for potential safety hazards and environmental impacts in accordance with the Tandem Van de Graaff Experimental Safety Review Procedure (See TVDG SEAPPM 1.3.5.), which has been approved by the Group Leader and Department Chair. The procedure includes guidelines for determining which activities require review by the Tandem Safety Committee. For projects that are not initiated by outside users, the Principal Investigator or project manager is responsible for informing the committee of projects requiring review and for providing necessary documentation.

Outside users of the Facility are required to complete a checklist that includes safety concerns. The Operation Supervisor brings any significant safety issues to the attention of the committee.

The committee reviews safety related issues and makes recommendations to the Group Leader. If the committee determines that the project requires external review, S&EP is notified.

8) Accelerator Safety Envelope

The Accelerator Safety Envelope for the TVDG Facility consists of the following Operational Safety Limits (OSLs) which were presented in their entirety in Chapters 4 and 6. The underlying basis for these limits is also detailed in those chapters.

OSL_RADSAFE_1

OSL_IGHS_1

OSL_IGHS_2

OSL_IGHS_3

OSL_IGHS_4

OSL_ACCL_1

OSL_OPS_1

It is the responsibility of the Operations Supervisor to ensure that periodic maintenance prescribed in the OSLs is performed according to schedule. The PERM program informs the operations staff of the required maintenance and testing. The Operations Supervisor shall not allow the accelerators to be operated in violation of the OSLs.

9) Quality Assurance

The Physics Department Chair has formally delegated responsibility for Quality Assurance at the TVDG facility to the TVDG Group Leader and his designated Q.A. representative. A Quality Assurance Manual, based on the Physics Department Q.A. Manual, but addressing the specific needs of the facility, has been developed. The manual includes requirements for documentation, design and fabrication, purchasing, equipment calibration and safety activities.

10) Decommissioning and Decontamination Plan

Primary concerns relating to decommissioning and decontamination of the accelerators would be the potential for the existence of large quantities of chemical, radioactive or mixed waste that would be difficult or expensive to dispose of. The insulating gas, which is present in large quantities, has commercial value and would not be classified as waste. Hazardous chemicals to be disposed of are present only in small quantities and would not be expected to present significant disposal problems. Outside users of the accelerator are not allowed to leave chemicals for disposal by the facility. The facility does generate small quantities of radioactive waste during operation. In most operating modes, the accelerators are incapable of causing activation. However, for lighter ions at higher energies, activation is possible. A small number of targets that have been exposed to primary beam might be classified as mixed waste. Under unusual circumstances, outside users of the accelerator are allowed to leave targets at the facility with the permission of the Operations Supervisor, who is then responsible for disposition of the targets. Such cases are rare. Nearly all user items that have been activated are shipped to the user as radioactive material. Some accelerator components are activated by accelerator operation. The activation is low level and does not create major difficulties in handling the components. These components would have to be disposed of as low level radioactive wastes when the accelerator is decommissioned. The TVDG Facility has been in operation for approximately 25 years. It is not expected that the quantity of activated material is being substantially increased by continued operation. The Cs sources in use in the accelerators can be surplussed or disposed of without difficulty.

Other than the disposal of these wastes, the decommissioning of the TVDG facility would not be expected to present any hazards beyond those usually associated with dismantling and moving large equipment.

11) References/Glossary/Abbreviations

11.1) References

Accelerator Safety Implementation Plan for Tandem Van de Graaff Facility
Tandem Van de Graaff Facility Conduct of Operations Conformance Matrix
Tandem Van de Graaff Quality Assurance Manual
Emergency Plan - Tandem Van de Graaff/Building 901A
Physics Department Safety and Environmental Policy and Procedures Manual (SEAPPM) -
includes TVDG sections
Environmental, Safety and Health Introduction to Building 901A
TVDG Operations Procedures Manual
TVDG Maintenance Procedures Manual
TVDG Pumping Instructions
Physics Department Training Plan
Tandem Operations Minimum Skill Requirements
Safety Analysis Report for the HITL-to-Booster (HTB) Heavy Ion Beamline
Tandem Van de Graaff/Alternating Gradient Synchrotron Heavy Ion Transfer Line Project

11.2) Acronyms and Abbreviations

This list contains acronyms and abbreviations not specific to the Tandem Facility. For acronyms and abbreviations specific to the Tandem, see the glossary on the next page.

AGS	Alternating Gradient Synchrotron
ALARA	As low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BNL	Brookhaven National Laboratory
CPR	Cardiopulmonary resuscitation
DACUM	Define a curriculum
DOE	Department of Energy
ES&H	Environment, Safety and Health
HAZCOM	Hazard communication
HFBR	High Flux Beam Reactor
HVAC	Heating, ventilating and air conditioning
HVEC	High Voltage Engineering Corporation
LN ₂	Liquid nitrogen
MPM	Maintenance Procedures Manual
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
OPM	Operations Procedures Manual
OSHA	Occupational Safety and Health Administration
OSL	Operational Safety Limit
PA	Public address
PCB	Polychlorinated biphenyl
POC	Product of combustion
QA	Quality Assurance
RHIC	Relativistic Heavy Ion Collider
SAR	Safety Analysis Report
SEAPPM	Safety and Environmental Administrative Policy and Procedures Manual
SEP	Safety and Environmental Protection
SAD	Safety Assessment Document
TLV	Threshold Limit Value

11.3) Facility Glossary

This list contains acronyms and abbreviations specific to the Tandem Facility. For acronyms and abbreviations not specific to the Tandem, see the list on the previous page.

	Building Equipment Room
BE Room	
EE Room	Electrical Equipment Room
HE End or Zone	High energy end or zone - Area of the accelerator room surrounding the high energy (output) end of one of the accelerators
HITL	Heavy Ion Transfer Line - Original beamline connecting Tandem to AGS. Also used to refer to the tunnel
HTB	HITL to Booster - Beamline or tunnel addition connecting HITL to Booster
LE End or Zone	Low energy end or zone - Area of the accelerator surrounding the low energy (input) end of one of the accelerators
ME Room	Mechanical Equipment Room
MP6	Model/Serial number of one of the Tandem accelerators
MP7	Model/Serial number of one of the Tandem accelerators
NII	Negative Ion Injector
PERM	Periodic Maintenance - A computer program developed at the facility that prompts personnel to perform maintenance or other procedures with a scheduled frequency and records their completion. For further description, see the TVDG OPM.
TRx	Target Room x
TTB	Tandem to Booster - HITL plus the HTB extension
TVDG	Tandem Van de Graaff

12) Appendices

Appendix I: Tandem Van de Graaff Radiation Control Responsibilities

Appendix II: Facility Life Safety Code Analysis

Appendix III: Facility Fire Hazard Analysis and Fire Protection Assessment

Appendix IV: Radiation Safety and Access Control System Logic

Appendix V: Negative Ion Injector High Voltage Interlock Logic

Appendix VI: Toxicity Analysis of TVDG Insulating Gas Mixture

Appendix VII: Air Activation by TVDG Beams

Appendix VIII: Hazard Classification for the Tandem Van de Graaff Facility

Appendix IX: Building 901A Shielding Effectiveness Studies

Appendix I

Tandem Van de Graaff Radiation Control Responsibilities

TANDEM VAN DE GRAAFF RADIATION CONTROL RESPONSIBILITIES

I. Facility Group Leader responsibilities:

- A. Defining radiation safety policy
- B. Authorizing bypassing of radiation safety systems
- C. Approving new systems and major modifications to existing systems related to radiation safety, access control and monitoring.

II. Tandem Safety Committee responsibilities:

- A. Reviewing significant changes in function or operation of existing radiation monitoring and safety systems
- B. Reviewing modifications of accelerator related shielding, and performing shielding integrity studies when appropriate.
- C. Reviewing radiation exposures occurring within the Tandem Van de Graaff Facility brought to their attention by S&EP.
- D. Reviewing experiments, activities and equipment with significant radiological safety concerns.
- E. Informing the AGS/Tandem/RHIC ALARA Committee of projects or activities that require review by that committee.

III. Chief Electrical Engineer responsibilities:

- A. Ensuring annual calibration of radiation monitors maintained by the facility
- B. Maintaining and testing radiation monitors that are the responsibility of the Tandem Van de Graaff Facility
- C. Maintaining and testing the radiation safety access control system. Approving modifications to system function or operation. Referring significant changes to the Tandem Safety Committee for review.

IV. Operations Supervisor responsibilities:

- A. Day-to-day implementation of radiation safety policy
- B. Ensuring appropriate radiological training of operations staff and outside users.

Approved



Date

8/29 1995

Appendix II

Facility Life Safety Code Analysis

This Appendix includes the Building 901A Life Safety Code Analysis performed in 1992 and a limited addendum performed in 1994. The sole remaining recommendation as of 1995 is LSC92-901A-5, which recommends modification of a stairwell. This modification is included as part of Life Safety Code Improvements Phase II.

**Life Safety Code Analysis
Brookhaven National Laboratory
Building 901A, Tandem Van de Graaff Facility**

Prepared by: J. A. Eckroth

Reviewed by: J. W. Lyesque

Date of Survey: Feb. 24, 1992

Date of Report: Feb. 28, 1992

Conferred with: J. Throwe, Safety Coordinator, TVdG Facility
K. Smith, Group Safety Supervisor, TVdG Facility

Scope

This is an analysis of the level of life safety (ie: the ability of occupants to exit during a fire) and compliance with the Life Safety Code (LSC)¹. Compliance with the Life Safety Code is required by DOE Order 5480.7².

Summary

The uses of the building, as described under "Occupancy", below, are based on the survey and on discussions with J. Throwe and K. Smith. The building complies with most aspects of the LSC and is acceptable for continued occupancy. Six deficiencies exist for which corrective measures are recommended.

Recommendations

LSC92-901A-3 The horizontal sliding door at the west entrance to the accelerator room and the horizontal sliding doors at the entrance to target rooms 1, 2, and 3 need to be repaired or replaced due to the excessive force that is presently required to open and close these doors.

LSC92-901A-5 The interior stairs leading from the basement computer room area needs to be adequately separated from other parts of the building. The stairs should discharge directly to the outside via exit passageway. The stair enclosure and exit passageway should meet the following separation requirements:

- The enclosure and passageway should be 1-hour fire rated.
- Openings into the enclosure and passageway should be limited to those necessary for access to the enclosure from normally occupied spaces, from corridors, and for egress

¹National Fire Protection Association No. 101, Life Safety Code, 1991 Edition

²US Department of Energy Order No. 5480.7, Fire Protection, 11/16/87

from the enclosure and passageway.

- All openings should be protected by 1-hour fire rated doors equipped with automatic door closures.
- Non-essential penetrations into and openings through an exit enclosure are not allowed. Therefore, the cable trays which are presently located in the stairway need to be relocated or separated from the stair enclosure.

LSC92-901A-6 The cable tray trenches which traverse between the first floor accelerator and target rooms and the basement mechanical equipment room need to be enclosed with a 1/2 hour fire barrier to provide separation between the first floor and basement.

Analysis

Building Construction

Building 901A is a one-story reinforced concrete building with a partial basement. The target and accelerator rooms are constructed of thick concrete shielding walls and roof. The building is earth bermed on the north side and on the roof of the target and accelerator rooms to provide additional shielding.

Interior walls of the office and laboratory areas are constructed of concrete block. The modular addition is of frame construction.

The building layout is shown on two diagrams in Attachment 1.

Fire Protection

Manual fire and evacuation alarms are installed throughout the building, including the target and accelerator rooms. Automatic sprinkler protection is provided in the basement mechanical equipment room. The remainder of the building is provided with an automatic fire detection system. A standpipe system is provided in several areas of the building. The control room and computer room are protected by Halon 1301 automatic fire protection systems. Alarms are arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and BNL Police Headquarters (Building 50).

Classification of Occupancy

The overall occupancy classification of Building 901A for LSC purposes is General Industrial. The accelerator and target rooms as well as the basement mechanical equipment room are Special Purpose Industrial occupancy areas. The offices and laboratories are incidental to the main occupancy.

Occupant Load

The General Industrial areas including the computer and control rooms, laboratories, offices, and associated areas covers approximately 19800 sq. ft. of floor area. Based on an occupant load factor of 100 sq. ft./person, the permitted occupant load for these areas is 198 people.

The accelerator rooms, target rooms, and basement mechanical equipment room, as Special Purpose Industrial occupancies, have no occupant load factor. Their occupant loads are based on the actual estimated maximum occupancy. The occupant loads of the accelerator rooms, target rooms, and basement mechanical equipment room are 12, 20, and 8 people, respectively.

Therefore, the total permitted occupant load for Building 901A is 238 people.

Means of Egress Components

With the exception of the items noted below, all doors, stairs, and ramps in Building 901A provide for an adequate means of egress in accordance with the LSC. There are no horizontal exits, exit passageways, fire escape stairs, or fire escape ladders serving this building.

The set of double doors in the corridor between the west office/lab area and the main building swings in the direction of exit travel for the main building. Therefore, this set of doors does not swing in the direction of exit travel for the west office/lab area. Since this set of doors serves as an exit for less than 50 people in the west office/lab area, this arrangement is acceptable (LSC-91, section 5-2.1.4.1).

The horizontal sliding door at the west entrance to the accelerator room and the horizontal sliding doors at the entrance to target rooms 1, 2, and 3 are in need of repair or replacement due to the excessive force that it presently required to open and close these doors (LSC-91, section 5-2.1.14.1; see recommendation LSC92-901A-3).

The interior stairs leading from the basement is a required exit for the basement computer room and therefore needs to be adequately separated from other parts of the building. In addition, as a required exit, the stairs needs to discharge directly to the outside. This can be accomplished by using an exit passageway between the top of the stairs and an outside exit. Non-essential penetrations into and openings through an exit enclosure are not allowed. Therefore, the existing cable trays located in the stairwell need to be relocated or separated from the stairway (LSC-91, sections 5-2.2.6.1 and 5-1.3.1; see recommendation LSC92-901A-5).

Capacity of Means of Egress

Exit capacity is based on the permitted occupancy load and on exit width factors, such as 0.2 inches/person for horizontal exit components and 0.3 inches/person for stairs.

There is adequate exit width from the building and from each area of Building 901A to accommodate the permitted occupant load.

Number and Arrangement of Means of Egress

With the exception of the items noted below, all areas of Building 901A are provided with an adequate number of properly arranged exits.

There is a 53 ft. dead-end corridor leading to the north laboratory in the west office area. This is in excess of the 50 ft. dead-end distance allowed by the LSC. The 3 ft. excess travel distance is considered a tolerable condition for this existing facility.

The common paths of travel for the control room on the first floor and the computer room in the basement are both in excess of the 50 ft. maximum allowed by the LSC. The existing common paths of travel for the control room and computer room are approximately 70 ft. and 90 ft., respectively. With the completion of recommendation LSC92-901A-5, these common paths of travel will be reduced to approximately 60 ft. each. While these reduced common paths of travel are still in excess of the 50 ft. standard, this condition is considered tolerable for the following reasons:

- Both rooms, along with the entire building, are provided with an early warning fire alarm system.
- Both rooms are protected by a Halon 1301 automatic fire protection system.
- Hazard of contents within the rooms, and along the entire path of exit egress, is considered to be low to ordinary.
- If necessary, a second means of egress through the accelerator room is available to the occupants of the control room.
- The calculated occupancy load of each room is 30 people, but due to equipment located within each room, the actual occupancy load of each room is expected to be a maximum of 15 people.

Another area of Building 901A where the common paths of travel exceeds the 50 ft. maximum allowed by the LSC is within target rooms 1, 2, and 4. The existing common paths of travel for these

rooms are approximately 90 ft., 70 ft., and 85 ft., respectively. While these common paths of travel are in excess of the 50 ft. standard, this condition is considered tolerable for the following reasons:

- All target rooms, along with the entire building, are provided with an early warning fire alarm system.
- Hazard of contents along the common paths of travel is considered to be very low. Hazard of contents along the entire path of exit access is considered to be low to ordinary.
- If necessary, a second means of egress through the accelerator room is available to the occupants of target room 4.
- The calculated occupancy load of each room is 30 people, but due to the nature of operations within each room, the actual occupancy load of each room is expected to be a maximum of 5 people.
- The reinforced concrete shielding walls of the target room are in excess of 2 ft. thick, making the installation of additional exits economically unjustifiable for the minimal additional life safety these doors would provide.

Travel Distances to Exits

Total travel distances to an exit from all areas of Building 901A are within the 200 ft. and 300 ft. LSC limitations for General Industrial and Special Purpose Industrial occupancies, respectively.

Discharge from Exits

With the exception of the interior stairs leading from the basement computer room area, all exits in building 901A discharge directly to a public way or at an exit discharge. As a required exit, the stairs from the basement computer room needs to discharge directly to the outside (LSC-91, section 5-7.1; see recommendation LSC92-901A-5).

Emergency Lighting and Marking of Means of Egress

Emergency lighting is provided in the exit access corridors and stairways of Building 901A as required by the LSC for Industrial occupancies. While not required by the LSC, all Special Purpose Industrial occupancy areas of Building 901A are also provided with emergency lighting.

All means of egress are adequately marked.

Protection of Vertical Openings

Although the inside stairway serving the basement computer room is a vertical opening, it is also a required exit. Therefore, this stairway needs enclosure protection in accordance with the more stringent requirements of exit enclosures rather than the requirements of vertical openings (see Means of Egress Components section, above).

There are several cable tray trenches which traverse between the first floor accelerator and target rooms and the basement mechanical equipment room. These cable tray trenches are considered vertical openings and are subject to the enclosure requirements of the LSC. Therefore, the cable tray trenches require an enclosure which will provide a 1/2-hour fire barrier separation between the first floor and basement (LSC-91, section 6-2.4.1; see recommendation LSC92-901A-6).

The elevator shaft between the basement and first floor is protected with 1 1/2-hour fire rated doors.

**Life Safety Code Analysis
Brookhaven National Laboratory
Building 901A, Tandem Van De Graaff Facility
Addendum #1, Cluster Klystron - Target Room #3**

Prepared by: _____
T. McEvaddy

Reviewed by: J. W. Levesque
J. W. Levesque

Date of Survey: August 26, 1994

Date of Report: August 29, 1994

Conferred with: J. Throwe, Safety Coordinator, RHIC Facility
K. Smith, Group Safety Supervisor, TVDG Facility

Scope

This report is an addendum to the Life Safety Code Analysis which was previously reported on 2/28/92. It's specific focus is Target Room #3. The remainder of the facility was not updated. This is an analysis of the level of life safety (ie: the ability of occupants to exit during a fire) and compliance with the Life Safety Code (LSC)¹. Compliance with the Life Safety Code is required by DOE Order 5480.7².

Summary

Enclosed figure #1 shows the layout of the new experiment in Target Room #3 of the Tandem Van De Graaff Experimental Hall (see Figure #1). This layout places the klystron (which is approximately 10 feet long) so as to be operated in a vertical configuration. A gantry with hoist will be erected to assist the assembly and disassembly of the klystron. Latter phases of the project plan are to construct an 8 feet high mezzanine. This high-voltage deck can then be conveniently removed and the klystron withdrawn to mezzanine height for disassembly, repair and/or testing.

The uses of the building, as described under "Occupancy", below, are based on the survey and on discussions with J. Throwe. The building complies with most aspects of the LSC and is acceptable for continued occupancy. Six deficiencies were cited on the report dated 2/28/92 for which corrective measures were implemented. There are no deficiencies cited on the Addendum #1 dated 8/29/94.

Recommendations

LSC92-901A-3 This deficiency does not apply to addendum #1.

These doors have been replaced so that excessive force is no longer required to open and close these doors.

¹National Fire Protection Association No. 101, Life Safety Code, 1991 Edition

²US Department of Energy Order No. 5480.7, Fire Protection, 11/16/87

LSC92-901A-5 This deficiency does not apply to addendum #1.

LSC92-901A-6 The cable tray trench which traverses between target room #3 and the basement mechanical equipment room need to be enclosed with a 1/2 hour fire barrier to provide separation between the first floor and basement.

These openings have been sealed up with metal plates and firestop materials which will ensure a 1/2 hour rated separation.

Analysis

Building Construction

The target Room #3 is constructed of concrete shielding walls and roof in excess of 2 feet. The building is earth bermed on the north side and on the roof of the target rooms to provide additional shielding.

The building layout is shown on the diagram in Attachment 2

Fire Protection

Manual fire and evacuation alarms are installed throughout the target rooms. Target Room #3 is provided with an automatic fire detection system. Alarms are arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and BNL Police Headquarters (Building 50).

Classification of Occupancy

The occupancy classification of Target Room #3 for LSC purposes is Special Purpose Industrial.

Occupant Load

Target room #3 as a Special Purpose Industrial occupancy, has no occupant load factor. Their occupant loads are based on the actual estimated maximum occupancy. The occupant load of Target Room #3 is 10 people.

Means of Egress Components

At Target Room #3 the existing 3'-0" pedestrian door w/ service leaf provides an adequate means of egress in accordance with the LSC. At the time of this report, there is an inoperative sliding shielding door which would not provide an adequate means of egress. There are no horizontal exits, exit passageways, fire escape stairs, or fire escape ladders serving this room.

Capacity of Means of Egress

Exit capacity is based on the permitted occupancy load and on exit width factors, such as 0.2 inches/person for horizontal exit components and 0.3 inches/person for stairs.

As per memo dated September 12, 1994, a 28" clear width egress path throughout the proposed layout will be required. This area is being classified as a special purpose industrial occupancy for evaluation under the 1994 LSC. In section 5-3.4 of the LSC with regard to minimum width states in Exception No. 3 that, "In existing buildings, the minimum width shall be not less than 28 in."

Based on the memo and indicated on the proposed klystron layout, this 28 in. dimension will be maintained except for a temporary period of time when the klystron cover is removed, at that time a point restriction to 24 in. will be present.

The department has agreed to mark the path with yellow tape on the floor surface.

There is adequate exit width from Target Room #3 of Building 901A to accommodate the permitted occupant load.

Number and Arrangement of Means of Egress

With the exception of the item noted below, Target Room #3 of Building 901A is provided with an adequate number and properly arranged exit.

A common path of travel less than 50 feet for Target Room #3 will be maintained at all times.

Travel Distances to Exits

Total travel distances to an exit from Target Room #3 is within the 300 ft. LSC limitations for Special Purpose Industrial occupancies.

Discharge from Exits

All exits from Target Room #3 in building 901A discharge directly to a public way or to an exit discharge.

Emergency Lighting and Marking of Means of Egress

Target Room #3, a Special Purpose Industrial occupancy area of Building 901A, is provided with emergency lighting.

All means of egress are adequately marked.

Protection of Vertical Openings

There is a cable tray trench which traverses between Target Room #3 and the basement mechanical equipment room. This cable tray trench is considered a vertical opening and is subject to the enclosure requirements of the LSC. Previously, the cable tray trench required an enclosure which would provide a 1/2-hour fire barrier separation between the first floor and basement (LSC-91, section 6-2.4.1; see recommendation LSC92-901A-6).

These floor openings have been sealed up with a combination of metal plates and firestop materials which will ensure a 1/2 hr rated separation.

Appendix III

Facility Fire Hazard Analysis and Fire Protection Assessment

This Appendix includes the Building 901A Fire Protection Assessment/Fire Hazard Analysis performed in 1992. The status of the recommendations in the report is as follows:

FPA-901A-1	Complete
FPA-901A-2	Complete
FPA-901A-3	Complete
FPA-901A-4	Included under Fire Protection Improvements Phase 5.
FPA-901A-5	Brookhaven National Laboratory Halon Phase-out Study has recommended that the halon system be replaced by an alternative gaseous suppression system.
FPA-901A-6	Funding for the connection of MP6 to the Heavy Ion Transfer Line will be requested.
FPA-901A-7	In progress. New drawings are electronically backed up and stored under halon protection. Old drawings are duplicated as time allows.
FPA-901A-8	Possible sources of funding are being discussed by Tandem and Fire Protection personnel.

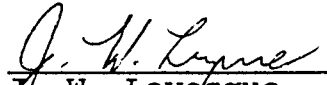
The Risk Assessments in Section 4 of the SAD with "Fire" as the hazard are based on the current status of these recommendations.

Fire Protection Assessment / Fire Hazard Analysis
Brookhaven National Laboratory
Building 901A, Tandem Van de Graaff Facility

Prepared by:


J. A. Eckroth

Reviewed by:


J. W. Levesque

Date of Survey: Feb. 24, 1992

Date of Report: Dec. 2, 1992

Conferred with: J. Throwe, Safety Coordinator, TVDG Facility
K. Smith, Group Safety Supervisor, TVDG Facility

Purpose/Scope

The purpose of this assessment is to evaluate the facility related fire protection aspects of Building 901A to ensure compliance with DOE fire protection criteria. DOE fire protection criteria is outlined in DOE Order 5480.7¹. A Fire Hazard Analysis, required for the Safety Analysis Report for this facility, is incorporated in this assessment.

Summary

The uses of the building, as described under "Occupancy and Associated Fire Hazards", below, are based on the survey and on discussions with J. Throwe and K. Smith. The level of fire protection in this building is sufficient to classify this building as an "improved risk", thereby meeting the objectives of DOE Order 5480.7. Seven items exist for which improvement measures are recommended.

Recommendations

1. Status of Recommendations from Previous Survey

Since this is an initial survey, there are no previous recommendations.

2. New Recommendations Resulting from the Current Survey

FPA92-901A-1 The corridor separating Building 901A from the combustible Modular Addition is provided with a 2-hour fire barrier. The door in this fire barrier is presently non-rated. To maintain the integrity of this fire barrier, the door should be upgraded to a 1 1/2-hour fire rated door and assembly.

¹US Department of Energy Order No. 5480.7, Fire Protection, 11/16/87

FPA92-901A-2 The non-rated doors and assemblies at the main entrance to the Control Room and at the entrance to the Accelerator Room from the Control Room should be upgraded to 1-hour fire rated doors and assemblies.

FPA92-901A-3 The penetrations through the fire barrier between the Accelerator Room in Building 901A and the HITL tunnel (Bldg 907) should be sealed with "KBS bags" or a similar type of fire-stopping to provide a 1-hour fire rating for this barrier.

FPA92-901A-4 The cable trays in the "tunnel like" area between the Accelerator Room and the basement Electrical Equipment Room present a special fire hazard due to the difficulty in accessing this area to provide manual fire fighting operations. Therefore, automatic sprinkler protection should be provided in this area.

FPA92-901A-5 The unsupervised key-operated abort switch on the Control Room Halon System should be removed. An acceptable alternative to the present abort switch arrangement would be to provide a supervised dead-man type abort switch in conjunction with a maximum 60 second discharge delay timer on the Halon activating circuit.

FPA92-901A-6 To reduce the probability of credible fire taking both accelerators out of service for an excessive period of time, a contingency plan should be developed which outlines the steps required to reroute the beam line from MP6 directly to the Heavy Ion Transfer Line, bypassing MP7 completely. In addition, the contingency plan should address the work required to upgrade the performance of MP6 so that it is capable of independently providing particle beams to the RHIC program. This contingency plan should be capable of being carried out within a six month period of time (or other time period acceptable to the DOE Program Senior Official). If a six month conversion time (or the time specified by the PSO) is unobtainable, consideration should be given to providing a permanent connection directly from MP6 to the Heavy Ion Transfer Line and upgrading the performance capabilities of the accelerator. This will result in a series/parallel connection from the accelerators to the transfer line which will reduce the overall probability of a credible fire taking both accelerators out of service at the same time.

FPA92-901A-7 As important records, the TVDG Experimental Setup Drawings should be duplicated and stored in a separate fire area of the building.

FPA/FHA, Building 901A, page 3

FPA92-901A-8 The standpipe system located in the office and stairwell area of the facility should be connected to the sprinkler/standpipe system located in the basement. In conjunction with this work, the additional fire department connection should be removed once the interconnection has been made.

Analysis

1. Construction

Building 901A is a one-story reinforced concrete building with a partial basement. The total building area, including the basement, is approximately 57,600 sq. ft. The Target and Accelerator Rooms are constructed of thick concrete shielding walls and roof. The building is earth bermed on the north side and on the roof of the Target and Accelerator Rooms to provide additional shielding.

Interior walls of the office and laboratory areas are constructed of concrete block. The 1400 sq. ft. Modular Addition is of frame construction.

The building layout is shown on two diagrams in Attachment 1.

The fire barrier integrity and the windstorm damage potential of Building 901A is expanded upon in sections 1.1 and 1.2, below.

1.1 Fire Barrier Integrity

The fire barriers required for Building 901A include; vertical cutoff between floors, separation barrier from Building 901, separation barrier from Modular Addition, separation barrier between the Control Room and adjoining areas, separation barrier between the Electrical Equipment Room and adjoining areas, and separation barrier between the Accelerator Room and HITL tunnel (Bldg 907).

The stairway opening between the basement and first floor of Building 901A contains a 1-hour fire rated barrier at the basement level which provides an adequate vertical cutoff between the two floors. However, this stairwell opening does not provide for an adequate exit enclosure as required for life safety purposes. In addition the cable tray penetrations in the stairway opening do not provide for an adequate vertical cutoff between the basement and first floor. Correction of this deficiency is addressed by recommendation LSC92-901A-5 in the Life Safety Code Analysis Report for Building 901A.

Another area of Building 901A which requires vertical cutoff (1/2 hour) between the basement and first floor are the cable tray trench openings between the Accelerator/Target Rooms and the basement Building Equipment Room. Presently, these unenclosed openings are not protected by adequate fire barriers. Correction of this deficiency is addressed by recommendation LSC92-901A-6 in the Life Safety Code Analysis Report for Building 901A.

Building 901A is adequately protected from Building 901 by a 30 ft. space separation. Both buildings are of fire resistive construction. The corridor connecting the two buildings is of non-combustible construction and provided with 2-hour fire barriers at each end.

Building 901A is separated from the wood-framed Modular Addition by a 20 ft. space separation. The corridor connecting the Modular Addition to the main facility is provided with a 2-hour fire barrier. The door in this 2-hour fire barrier is non-rated and needs to be upgraded to a 1 1/2-hour fire rated door (see recommendation FPA92-901A-1).

With the exception of two doors, the Control Room on the first floor of Building 901A is adequately separated from adjacent areas. The non-rated main entrance door and the non-rated sliding door which leads to the Accelerator Room are required to be 1-hour fire rated (see recommendation FPA92-901A-2).

The Electrical Equipment Room in the basement of Building 901A is adequately separated from adjacent areas by 1-hour fire rated barriers and openings.

The Accelerator Room in Building 901A is separated from the HITL tunnel (Bldg 907) by a 1-hour rated fire door and wall assembly. There are several cable and pipe penetrations in the wall assembly which are not adequately sealed to prevent the spread of fire (see recommendation FPA92-901A-3). The duct penetration through this 1-hour rated fire wall, although not provided with a fire damper, is acceptable per NFPA 90A, Installation of Air Conditioning and Ventilating Systems.

1.2 Windstorm Damage Potential

Due to the reinforced concrete construction and earth berming provided on a major portion of Building 901A, the windstorm damage potential at this facility is considered to be very slight.

2. Occupancy and Associated Fire Hazards

The overall occupancy of Building 901A can be classified as industrial. The main floor of the building is occupied by; two Accelerator Rooms, four Target Rooms, a Control Room, a Mechanical Equipment Room, and offices and laboratories incidental to the main occupancy. The basement area of the building is occupied by an Electrical Equipment Room and a Building Equipment Room.

The two Accelerator Rooms (actually one continuous room with two accelerators located within) contain the Tandem Van de Graaff accelerators. The accelerators consist of steel vessels which are approximately 100 ft. long and 18 ft. in diameter. The two accelerators are located in-line in a room about 320 ft. long and 35 ft. wide. Spare parts for the accelerators are stored on wood shelves along the north wall of the Accelerator Room. There is a sub-mezzanine area within the Accelerator Room which contains accelerator related equipment, piping, and cable trays. The arrangement of the cable trays in the Accelerator Room is expanded upon in section 2.3.5, below. With the exception of the wood shelving and cable trays, combustible loading in the Accelerator Room is very light.

Each accelerator has an inert insulating gas made up of sulfur hexafluoride, nitrogen, and carbon dioxide at about 150 psig surrounding the support column and accelerating tubes. The accelerator tubes are maintained at a high vacuum. The insulating gas is supplied by tanks located in an earth cover outside the facility.

Each machine is capable of accelerating various particles, including heavy ions, with the resulting particle beams being directed by magnets to Target Rooms located in Building 901A. The west accelerator, MP6, normally directs particle beams to Target Room 1. The east accelerator, MP7, normally directs particle beams to Target Rooms 2 & 4. If higher energies are required, MP6 directs particle beams to MP7, where the particle beams are further accelerated before being directed to Target Rooms 2 & 4.

MP7 also has the capability of directing particle beams to the Heavy Ion Transfer Line in Building 907. This transfer line is intended to be used to transport heavy ion particle beams from the Tandem Van de Graaff facility to the Alternating Gradient Synchrotron (AGS) complex, where the beams will be further accelerated for use at the Relativistic Heavy Ion Collider (RHIC) complex now under construction. Since there is no direct connection from MP6 to the heavy ion transfer line in Building 907, MP6 is only capable of directing particle beams to the heavy ion transfer line if used in conjunction with MP7. In addition, the present performance limitations of MP6 does not allow this accelerator to independently provide the type of particle beams which will be required by the RHIC program. These conditions limit the recovery potential at this facility. The recovery potential is further described in section 4.3, below.

Target Rooms 1, 2, and 4 contain experimental equipment used in conjunction with the particle beams originating from the accelerators. Target Room 3 is no longer used as an experimental area. This room now contains control equipment associated with the Heavy Ion Transfer Line in Building 907. Cable tray trenches

connect the Target Rooms to the Control Room and Accelerator Room. The arrangement of the cable tray trenches in the Target Rooms is expanded upon in section 2.3.5, below. With the exception of the cables in the trenches, combustible loading in the Target Rooms is very light.

The basement Building Equipment Room is used mainly for HVAC type equipment and associated devices. In addition, a major portion of the cables to and from the Control Room pass through the basement Building Equipment Room. The arrangement of the cable trays in the basement Building Equipment Room is expanded upon in section 2.3.5, below. The room also has an area which is used to store various combustible materials, equipment, and packaging containers. The overall combustible loading in the basement Building Equipment Room is moderate. Automatic sprinkler protection is provided in this area.

The Mechanical Equipment Room located on the main floor contains equipment associated with the operation of the accelerators, such as pumps and compressors. There is also miscellaneous machine shop equipment located in this room. A flammable liquids storage cabinet is located on the north wall of this room. With the exception of the properly stored flammable liquids, combustible loading in this room is minimal. In addition, ignition sources are limited and an early warning detection system is provided. A credible fire in this area would not be expected to exceed \$250,000 or delay the operation of the accelerators for an excessive period of time.

The offices and labs located in the remainder of the building contain no unusual fire hazards. Combustible loading in these areas is moderate, but an automatic fire protection system in these areas is not warranted for the following reasons:

- While not fire rated, the area is well segregated with concrete block walls from floor to ceiling.
- The entire area is provided with an early warning heat detection system.
- The negative impact on the operation of the accelerators from a fire in the office area is considered minimal.
- The cost versus benefit ratio of providing an automatic protection system in this area is not advantageous.
- It is reasonable to assume that the BNL Fire Department would be able to mitigate the damages of a credible fire.
- The loss estimate from a credible fire in this area is expected to be less than \$250,000.

The occupancy of the Control Room and Electrical Equipment Room are expanded upon in section 2.2.1, below.

Critical process equipment, special occupancies, and unique fire hazards at Building 901A are expanded upon in sections 2.1 through 2.3, below.

2.1 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a credible fire, could delay a significant component of a major program for a period in excess of 6 months.

By the above definition, the accelerators and some of the associated equipment at Building 901A are considered to be critical process equipment. Critical process equipment outside of the accelerators is expected to have a replacement time of less than 6 months. This replacement period is considered acceptable by DOE standards.

Some of the equipment internal to the accelerators, most notably the accelerator tubes, may require a lead time in excess of 6 months for repair or replacement. However, it is highly unlikely that this equipment would be destroyed in a credible fire because of its physical location. In addition, it is even more improbable that the internal components of both accelerators would be damaged in a single fire occurrence. For further details regarding the recovery potential of the accelerators, see section 4.3, below.

2.2 Special Occupancies

Special occupancies include electronic data processing and vital/important records. The special occupancies of Building 901A are expanded upon in sections 2.2.1 and 2.2.2, below.

2.2.1 Electronic Data Processing

The Control Room located on the main level of Building 901A contains processing equipment associated with operating and monitoring the accelerators and experimental equipment. The room has a non-combustible raised floor with a large number of grouped cables located beneath the floor. The entire Control Room, including the subfloor area, is protected by a Halon 1301 Fire Protection System.

The Electrical Equipment Room located in the basement was originally designed for and contained a Xerox Data Systems computer for on-line analysis of experimental data. The room is no longer needed for this purpose and now only contains several cabinets of control and relay equipment

associated with the accelerators. The room also contains a temporary computer operation with a large number of electronic storage tapes not directly associated with the accelerator operations. The room has a non-combustible raised floor with a small amount of group cables located beneath the floor. The entire Electrical Equipment Room, including the subfloor area, is protected by a Halon 1301 Fire Protection System.

2.2.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

Building 901A records that would fall into the category of being either vital or important if an obtainable copy did not exist are as follows:

- 1) TVDG Operating Procedures Manual (Important)
- 2) TVDG Machine Drawings (Important)
- 3) TVDG PC Network Backup Tapes (Important)
- 4) TVDG Radiation Safety Systems Drawings (Important)
- 5) TVDG Experimental Setup Drawings (Important)
- 6) HITL/HTB Drawings (Important)
- 7) TVDG Safety Analysis Report (Important)

Obtainable copies presently exist for Item Nos. 1, 2, 3, 4, 6, & 7, above. The copies are located either in a separate fire area of Building 901A or completely off of the building premises. These obtainable copies eliminate the need to provide special protection for the original documents. As an important record, Item No. 5, above, should be duplicated and stored in a separate fire area of the building (see recommendation FP92-901A-7).

From the aspect of not being reproducible if lost, the TVDG Operations Logbooks could be considered vital records. However, the loss of the Logbooks would not preclude the facility from continuing to operate, thereby making the Logbooks non-essential to the mission of the program. From this standpoint, the Logbooks are not considered vital records. While not a requirement since the logbooks are

neither a vital or important document by definition, consideration should be given to making copies of the Logbooks. Copies would eliminate the concern that the Logbooks are not reproducible.

2.3 Unique Fire Hazards

Unique fire hazards include; modular buildings, trailers, cooling towers, flammable liquid & gas storage, cable trays, housekeeping in vital areas, and highly combustible building materials. The unique fire hazards of Building 901A are expanded upon in sections 2.3.1 through 2.3.7, below.

2.3.1 Modular Buildings

Building 901A has a 1400 sq. ft. Modular Addition located 20 ft. south of the main facility. The Modular Addition is of framed construction. The Modular Addition is connected to the main facility by a corridor provided with a 2-hour fire rated separation barrier. The fire door located in the fire barrier is presently substandard and requires upgrading (see recommendation FPA92-901A-1).

The Modular Addition has a 42 ft. wall length exposed to the main facility. With the exception of the connecting corridor, there are no substantial openings in the fire resistive walls of the main facility within the vicinity of the Modular Addition. Upon upgrading of the fire barrier in the connecting corridor, the exposure potential to the main facility from this Modular Addition will be considered minimal.

2.3.2 Trailers

There are no trailers associated with Building 901A.

2.3.3 Cooling Towers

The cooling tower associated with Building 901A is located on the roof on the east end of the facility. The cooling tower is constructed of wood and plastic. The cooling tower is used in conjunction with building chiller equipment only during warm weather. A loss of the cooling tower could cause a temporary shutdown of the accelerator operations, but an excessive replacement time is not anticipated.

2.3.4 Flammable Liquid & Gas Storage

The amount of flammable liquids stored in Building 901A is minimal. Storage is generally restricted to a safety cabinet located in the first floor Mechanical Equipment Room. Incidental use and storage outside of the flammable

liquid storage cabinet does not exceed the quantities allowed by NFPA 30, Flammable and Combustible Liquids Code.

Flammable gas cylinders are properly stored outside on the loading dock at the southwest end of the building.

2.3.5 Cable Trays

Each Target Room has a cable trench about 2 ft. deep and 3 ft. wide which traverses the room. The trenches contain three cable trays stacked vertically plus utilities such as chilled water and compressed air. The trenches are provided with metal encapsulated plywood covers. The trenches open up to the basement Building Equipment Room where the cable trays are then routed to the Control Room. Smoke detectors are located in the cable tray trenches at the point where the trenches open up to the basement Building Equipment Room. At the present time, no fire stops are provided in the cable tray trenches between the first floor Target Rooms and the basement Building Equipment Room. Correction of this deficiency is addressed by recommendation LSC92-901A-6 in the Life Safety Code Analysis Report for Building 901A.

In each of the Target Rooms, the trench system terminates in a metal cabinet about 2 ft. by 2 ft. by 6 ft. high. These cabinets act as patch boards between the experimental equipment in the Target Rooms and the Control Room. Each cabinet is equipped with a smoke detector.

As indicated above, all control cables between the Control Room and the Target Rooms pass through the basement Building Equipment Room. These cables are located in trays along the north wall of the room and are stacked vertically up to 9 trays high. Automatic sprinkler protection is provided throughout the basement Building Equipment Room.

The Accelerator Room has 4 cable trays located in the sub-mezzanine area of the room which route cables from the Accelerator Room to the Target Rooms and to the Electrical Equipment and Control Rooms. The major portion of the trays are stacked vertically along the north wall of this sub-mezzanine area and in a "tunnel like" area between the Accelerator Room and Electrical Equipment Room.

Throughout this facility, high voltage (440 volts & less), low voltage, control, and signalling cables are generally segregated in the cable trays. The high voltage cables are in most instances located on the bottom rack. In most instances, the cables are not provided with a flammability hazard rating, but are generally considered to be Group 3 (highest flammability hazard).

The cable trays are constructed of a open grated sheet metal material, generally 12 in. wide. The spacing between adjacent trays is generally 8 to 12 in. Each cable tray is provided with a single plastic bag filled with vermiculite to act as fire stops. The bags are located at 30 ft. intervals along the entire length of the trays.

With the exception of the cable trays in the "tunnel like" area connecting the Accelerator Rooms to the Electrical Equipment Room, all cable trays are easily accessible to manual fire fighting operations. Automatic sprinkler protection is recommended for the "tunnel like" area noted above due to the difficulty of providing manual fire fighting operations in this area (see recommendation FPA92-901A-4).

2.3.6 Housekeeping in Vital Areas

Housekeeping in vital areas including the Accelerator Room, Target Rooms, Control Room, and Electrical Equipment Room is acceptable.

2.3.7 Highly Combustible Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at Building 901A.

3. Fire Protection/Suppression Features

Manual fire alarm pull stations are installed throughout the building, including the Target and Accelerator Rooms. A building evacuation alarm pull station is located in the front lobby. Unsupervised fire alarm bells are located throughout the facility.

Automatic sprinkler protection is provided in the basement Building Equipment Room. This system is hydraulically designed to provide a density of 0.20 gpm over a 3000 sq. ft. area. Two standpipe systems are provided for this facility. One standpipe system has connections located in the office area and stairwell area of the facility and is fed from the domestic supply for the building. The other standpipe system has connections located in the basement of the facility and is fed from the automatic sprinkler system in the basement area. There is a separate fire department connection for each of these two standpipe systems.

To eliminate the confusion that could result from have two fire department connections for two separate systems in the same facility, the standpipe system located in the office and stairwell area of the facility should be connected to the sprinkler/standpipe system located in the basement. In

conjunction with this work, the additional fire department connection should be removed once the interconnection has been made (see Recommendation FPA92-901A-8).

The remainder of the building is provided with an automatic fire detection system. This system consists of heat detectors through the office areas, Control Room, Electrical Equipment Room, and first floor Mechanical Equipment Room. The Accelerator Room and the Target Rooms are provided with both heat detectors and smoke detectors.

The Control Room and Electrical Equipment Room are each protected by independent Halon 1301 Automatic Fire Protection Systems. These systems are designed to discharge a 5% concentration of Halon 1301 within the corresponding room and associated raised floor area. During the initial acceptance test on the systems, records indicate a 5% concentration was maintained for a period of 3 1/2 to 4 minutes. Each system is designed to discharge upon initiation of a single zone heat detection circuit or manual release station. A smoke detection circuit is also provided on the system. This circuit is arranged to provide an alarm on the system but will not discharge the Halon. The Halon control panels are monitored by the building fire alarm system.

An unsupervised key-operated abort switch is provided on the Control Room Halon system. When activated this switch disarms the Halon system, preventing the system from operating automatically. In the event of a fire while the Halon system is disarmed, manual action must be taken to activate the system. Operating procedures indicate that the system is to be disarmed (Halon system aborted) during normal operating periods and is to be armed (Halon system automatic) during non-operating periods.

The present arrangement of the abort switch in the Control Room is undesirable for the following reasons:

- An incident occurring during operating periods may not allow the operator to arm the system, thereby leaving the Control Room unprotected.
- If accidentally left disarmed, the Control Room could be left without automatic protection during non-operating periods.

An acceptable alternative to the present abort switch arrangement would be to leave the system armed at all times and provide the following:

- A supervised dead-man type abort switch.
- A maximum 60 second discharge delay timer on the Halon activating circuit.

With this arrangement an operator would have 60 seconds to activate and hold an abort button in the event of a false alarm. In the event of an actual fire the Halon system would activate upon expiration of the 60 second discharge delay, if the abort button is not being held in. The system could also be activated immediately by pulling the manual release station (see recommendation FPA92-901A-5).

The building fire alarm system is arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and BNL Police Headquarters (Building 50).

An adequate number of properly rated hand-held fire extinguishers are located throughout this facility.

The fire protection/suppression features of vital programs, high valued property, and essential safety class systems at Building 901A are expanded upon in sections 3.1 through 3.3, below.

3.1 Fire Protection of Vital Programs

No singular aspect of this facility is considered a vital program, but the facility as a whole is a significant program. Upon completion of the Relativistic Heavy Ion Collider (RHIC) complex, the importance of this facility as it relates to achieving the goals of the RHIC program will be amplified. An acceptable shutdown period has not been defined for this facility, therefore a maximum shutdown period of 6 months is being used as a default as indicated in DOE Order 5480.7.

The fire protection features presently provided at this facility, and the recommendations provided in this report, should prevent a credible fire from delaying this important program in excess of six months.

3.2 Fire Protection of High Value Property

Much of the property associated with the Tandem Van de Graaff accelerators and the experimental equipment in the Target Rooms is considered to be high valued property. However, due to the fire resistive construction and relatively low combustible loading throughout these areas, a maximum possible fire would not be expected to cause damage in excess of \$1 million.

A maximum possible fire in the basement Building Equipment Room or in the Control Room could be expected to exceed \$1 million. The fire protection systems presently provided in these areas should limit this dollar loss expectancy to an acceptable level (under \$250,000).

3.3 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

4. Fire Loss Potentials

Fire loss potentials are classified into three major categories; the maximum credible fire loss, the maximum possible fire loss, and the recovery potential. The loss potentials for Building 901A are expanded upon in sections 4.1 through 4.3, below.

4.1 Maximum Credible Fire Loss (MCFL)

The Maximum Credible Fire Loss (MCFL) for any given area of Building 901A is expected to be less than \$250,000. Typical areas where a loss of this magnitude could be expected to occur include; cable trays in the Accelerator Rooms, ion source equipment for the accelerators, Control Room equipment, first floor Mechanical Equipment Room, basement Building Equipment Room, and the wood construction Modular Addition. The fire protection features at this facility are sufficient to restrict the estimated MCFL to within acceptable loss limitations specified by DOE.

4.2 Maximum Possible Fire Loss (MPFL)

The Maximum Possible Fire Loss (MPFL) for this facility is estimated to be the result an uncontrolled fire in the Control Room. Assuming a loss of all Control Room equipment and extensive damage to the associated cabling, a loss in excess of \$2 million dollars could be anticipated. The fire protection features presently provided for the Control Room, and the recommendations provided in this report, should prevent a MPFL of this nature from occurring in this area.

4.3 Recovery Potential

While having a relatively low probability of occurring, it is foreseeable that a credible fire in the Accelerator Room cable trays could cause a shutdown of at least one of the two accelerators at this facility for an excessive period of time. The probability of this shutdown impacting the future Relativistic Heavy Ion Collider (RHIC) program is increased by the fact that if MP7 is involved in a credible fire, MP6, even if undamaged, will not be readily capable of providing heavy ion particle beams to the RHIC complex. This is due to the fact that MP6 is in series with MP7, and is therefore not capable of directly feeding particle beams to the heavy ion transfer line in Building 907. In addition, the present performance limitations of MP6 do not allow this accelerator to independently provide the type of particle beams which will be required by the RHIC program.

To reduce the probability of a credible fire taking both accelerators out of service for an excessive period of time, a contingency plan should be developed which outlines the steps required to reroute the beam line from MP6 directly to the

Heavy Ion Transfer Line, bypassing MP7 completely. In addition, the contingency plan should address the work required to upgrade the performance of MP6 so that it is capable of independently providing particle beams to the RHIC program. This contingency plan should be capable of being carried out within a six month period of time (or other time period acceptable to the DOE Program Senior Official). If a six month conversion time (or the time acceptable to the PSO) is not obtainable, consideration should be given to providing a permanent connection directly from MP6 to the Heavy Ion Transfer Line and upgrading the performance capabilities of the accelerator. This would result in a series/parallel connection from the accelerators to the transfer line which would reduce the overall probability of a credible fire taking both accelerators out of service at the same time (see recommendation FPA92-901A-6).

5. Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility.

6. Exposure Fire Potential

Exposure fire potential at Building 901A is limited to the possible exposure from Building 901, the HITL tunnel (Bldg 907), and the Modular Addition. All three of these structures are interconnected to Building 901A. The fire barriers and space separations associated with these exposures are discussed in section 1.1. There are no additional fire exposures beyond those noted above.

7. Environmental Impact due to a Fire (Including Water Runoff)

Toxic, biological, and radiation incidents resulting from a fire, including water runoff, could have an impact on the environment. The potential for these incidents occurring at Building 901A are expanded upon in sections 7.1 through 7.3, below.

7.1 Toxic Incident

There are no known materials in Building 901A that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

The only chemical material present in significant quantities at this facility is the insulating gas mixture used in the accelerator pressure vessels. This mixture contains SF₆, N₂, and CO₂. Each pressure vessel contains a gas mixture volume of

11,250 cu. ft. at atmosphere and is pressurized during operations to a nominal 70 psig for MV6 and 180 psig for MV7. When the pressure vessels are open, the gas is stored in one of the two banks of buried storage vessels on top of 901A. The only known hazard the gas mixture poses is the potential for an oxygen deficient atmosphere (asphyxiation hazard).

The potential of gas escapement in a fire situation is very slight. A manual emergency exhaust ventilation system is available to purge the facility in the event of a major leak in the gas system.

Chemically reactive elements and compounds are used in 901A. However, only small quantities are used and stored and all applicable ES&H Standards are adhered to. An inventory of all chemicals used in Building 901A is available at the facility.

7.2 Biological Incident

Due to the lack of biological matter at this facility, an incident of this type is unforeseeable.

7.3 Radiation Incident

There are four areas where radioactive materials are stored in 901A. Two of the storage areas are lead "check source" cabinets containing a variety of isotopes. Neither of the cabinets contain an accountable amount of nuclear material. One of the cabinets is located in Accelerator Room 2, just outside the Control Room shield door. The other cabinet is located in the Mechanical Equipment Room, near the door to the ion source lab. None of the radioactive materials at this facility are subject to an off-site release.

8. Prefire and Emergency Planning

The BNL Fire Department maintains an adequate prefire plan book for this facility. An adequate local emergency plan is maintained by the Tandem Van de Graaff department.

8.1 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate at this facility.

9. Life Safety Considerations

Life safety considerations are fully addressed in the Life Safety Code Analysis report for this facility, dated February 28, 1992.

Appendix A

Blind Recommendations

This appendix provides documentation for recommendations which are in the best interest of fire prevention but for which corrective action is not considered to be cost beneficial.

FPA92-901A-BR1 To reduce the overall combustibile loading in the Accelerator Rooms, the wood shelving used to store spare parts should be replaced with a non-combustible material.

Comments: Storage of spare parts in the Accelerator Rooms is provided on the north wall using wood shelves. To reduce the possibility of these wood shelves becoming involved in a credible fire, consideration should be given to replacing these shelves with a non-combustible material.

The probability of the wood shelves becoming involved in a credible fire is very low. In addition, the effort required to replace the wood shelving is extensive. Therefore, this existing situation is considered tolerable. If future modifications to the facility such as the connection of MV6 to HITL involves temporarily moving the wood shelves, efforts should be made at that time to replace the wood shelves with a non-combustible material.

FPA92-901A-BR2 The fire alarm bell circuit throughout this facility should be rewired in a series type arrangement to allow supervision of the circuit.

Comments: Unsupervised fire alarm bells are located throughout the facility. The bell circuit is not supervised due to the extensive "tee" tap wiring pattern of the circuit.

The non-supervised bell circuit was in compliance with NFPA requirements at the time it was originally installed. The expense involved in modifying the bell circuit to allow supervision is extensive, making this recommendation uneconomical. During the semi-annual testing of the bell circuit, no incidents of the bell circuit failing to operate have been noted. In addition, the fire alarm panel located next to the receptionist area is provided with a supervised sonalert alarm. In addition, the entire system is designed to alarm remotely at the BNL Fire/Rescue Headquarters through a supervised proprietary system.

FPA92-901A-BR3 The single zone heat detection systems used to actuate the Halon fire protection systems in the Control Room and electrical equipment room should be converted to cross-zoned smoke detection systems.

Comments: Halon fire protection systems are designed to extinguish fires in the early stages of their development. Excessive damage could occur to the equipment in the Control Room and Electrical Equipment Room due to the delays inherent with heat detection systems. In addition, a single zone system increases the probability of a false alarm inadvertently activating the Halon system.

The work required to convert these systems to cross-zoned smoke detection systems is considered uneconomical. The existing systems are relatively old (detection circuit is 220 VDC), thereby requiring the control panels to be replacement. Smoke detection systems (alarm only) are provided throughout the Control Room and Electrical Equipment Room.

FPA92-901-BR4 The power and signaling cable trays located in areas of the building not protected with automatic sprinklers should be replaced with Group 1 type cabling or automatic sprinkler protection should be provided for these cable trays.

Comments: Each Target Room has a cable trench about 2 ft. deep and 3 ft. wide which traverses the room. The trenches contain three cable trays stacked vertically.

All control cables between the Control Room and the Target Rooms pass through the basement Building Equipment Room. These cables are located in trays along the north wall of the room and are stacked vertically up to 9 trays high. Automatic sprinkler protection is provided throughout the basement Building Equipment Room.

The Accelerator Rooms have 4 cable trays located in the sub-mezzanine area of the rooms which route cables from the Accelerator Rooms to the Target Rooms and to the Electrical Equipment Rooms. The major portion of the trays are stacked vertically along the north wall of this sub-mezzanine area and in a "tunnel like" area between the Accelerator Rooms and the Electrical Equipment Room.

Throughout this facility, high voltage (440 volts & less), low voltage, control, and signalling cables are generally segregated in the cable trays. The high voltage cables are in most instances located on the bottom rack. In most instances, the cables are not provided with a flammability hazard rating, but

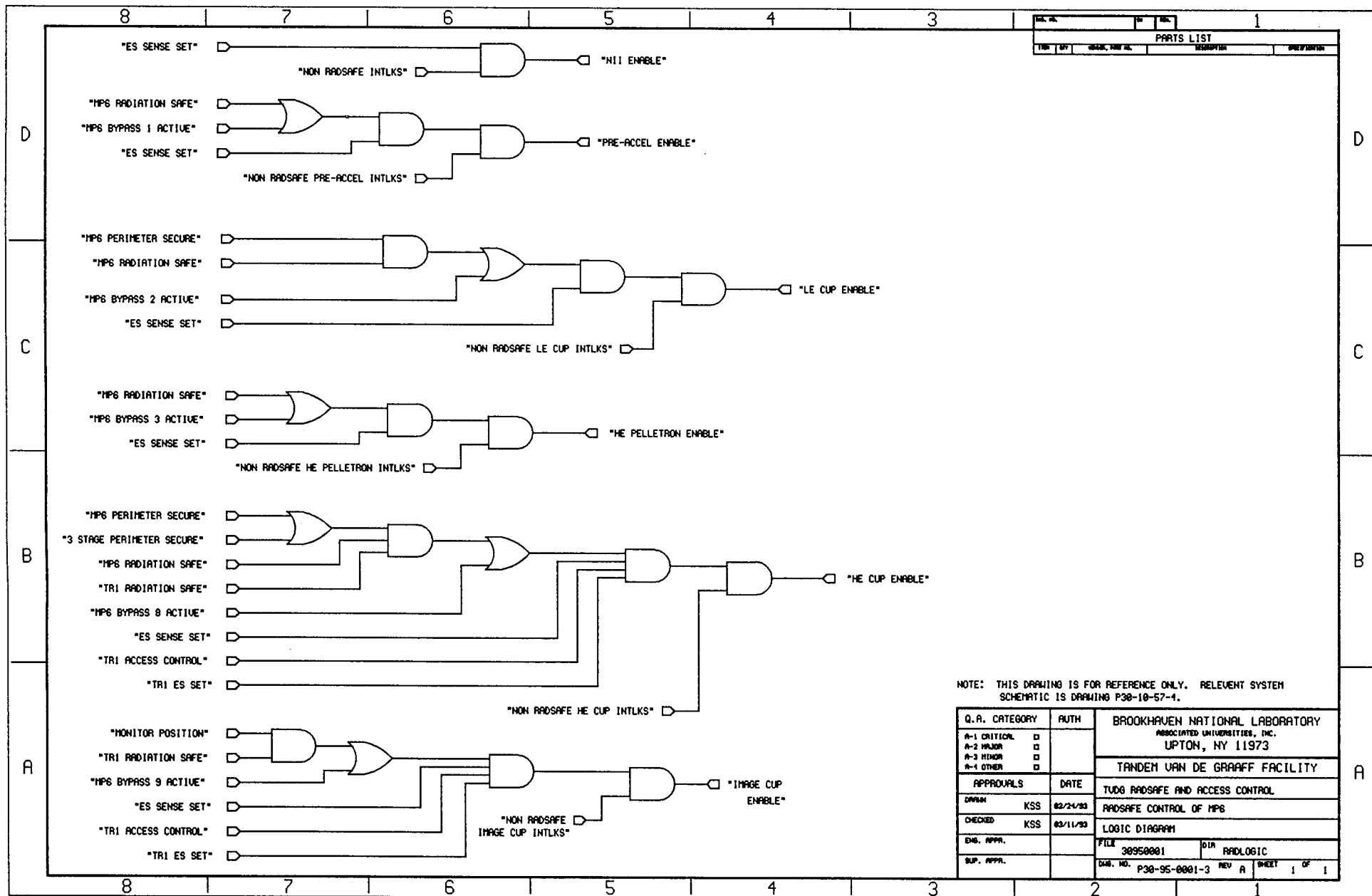
are generally considered to be Group 3 (highest flammability hazard).

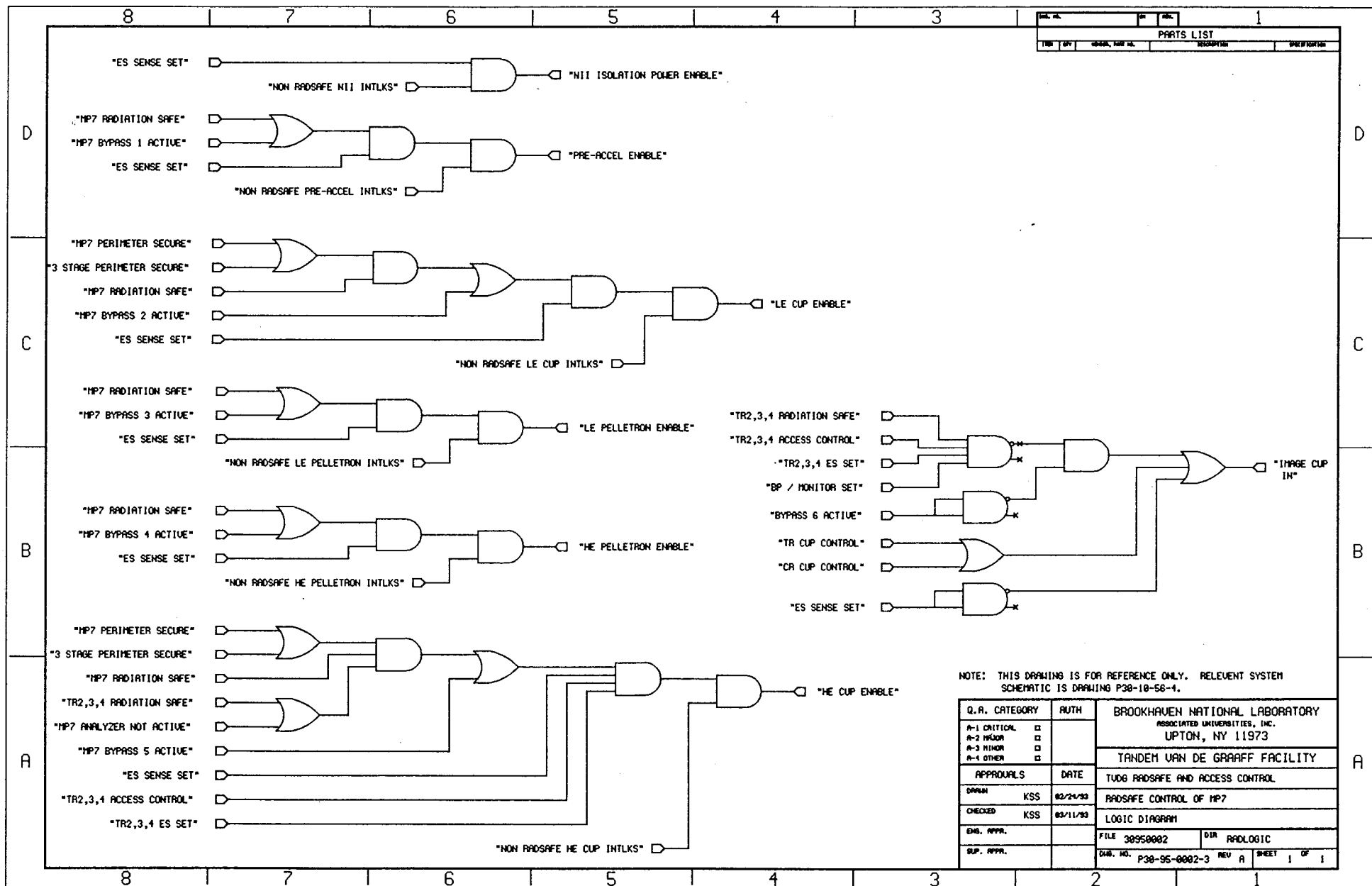
The cable trays are constructed of a open grated sheet metal material, generally 12 in. wide. The spacing between adjacent trays is generally 8 to 12 in. Each cable tray is provided with a single plastic bag filled with vermiculite to act as fire stops. The bags are located at 30 ft. intervals along the entire length of the trays.

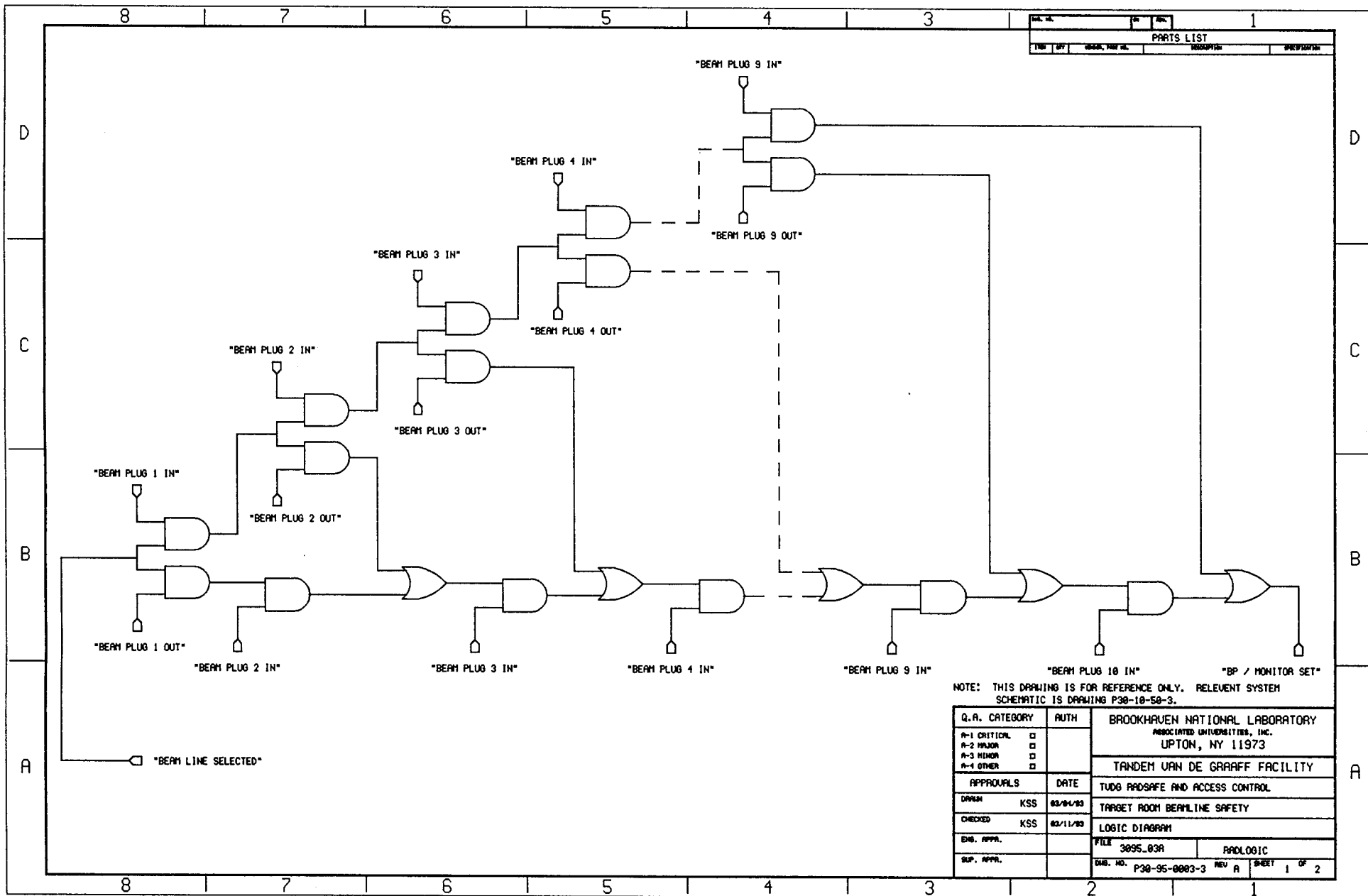
The changes required to comply with this recommendation are considered uneconomical. With the exception of the cable trays in the "tunnel like" area connecting the Accelerator Rooms to the Electrical Equipment Room (see recommendation FP92-901A-4 for additional details on this area), all cable trays are easily accessible to manual fire fighting operations. In addition, smoke detection is provided in all areas containing unprotected cable trays. The MCFL for a cable tray fire at this facility, without the provisions of this recommendation, is estimated to be within the acceptable loss limitations specified by DOE.

Appendix IV

Radiation Safety and Access Control System Logic



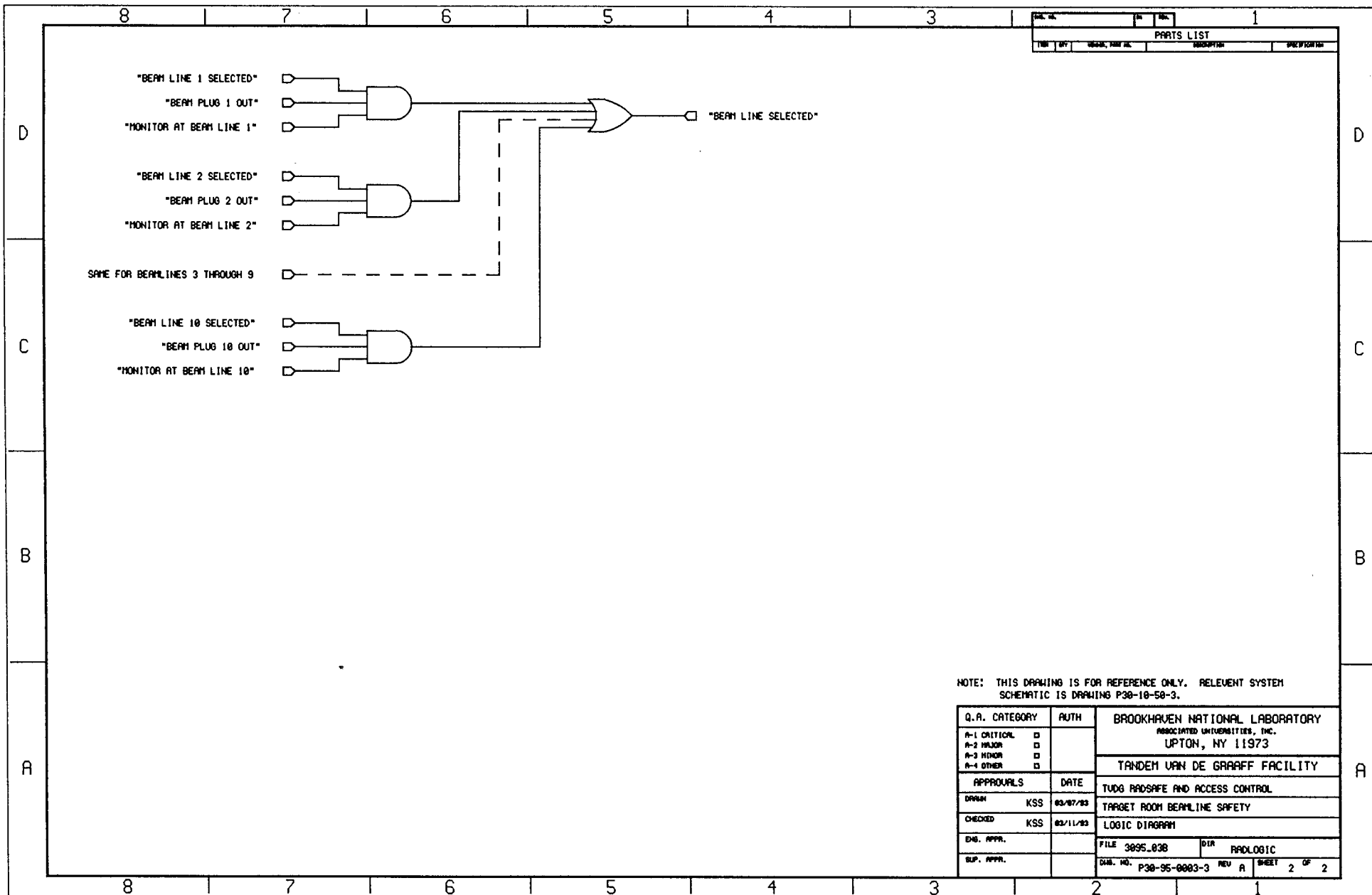


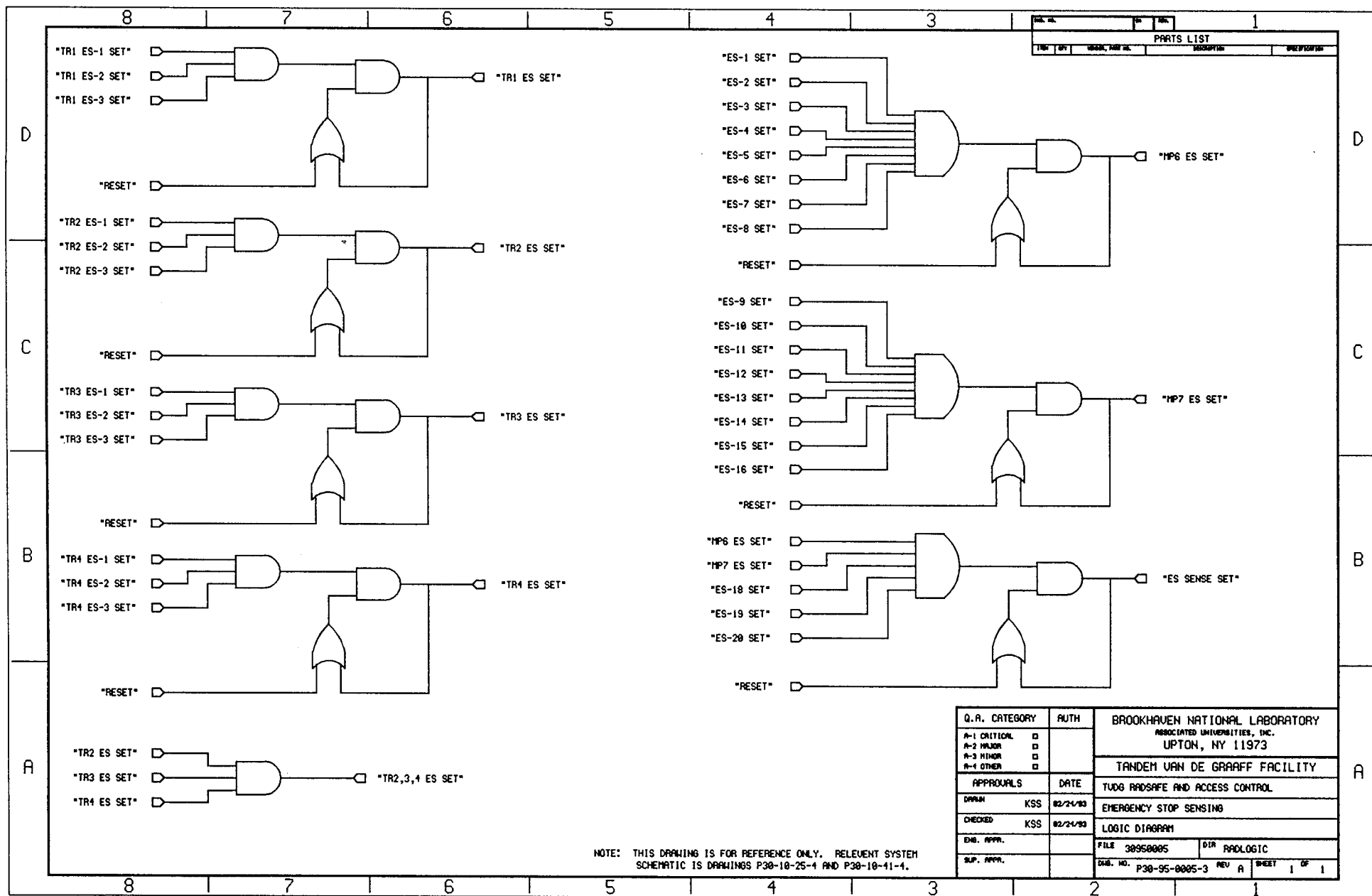


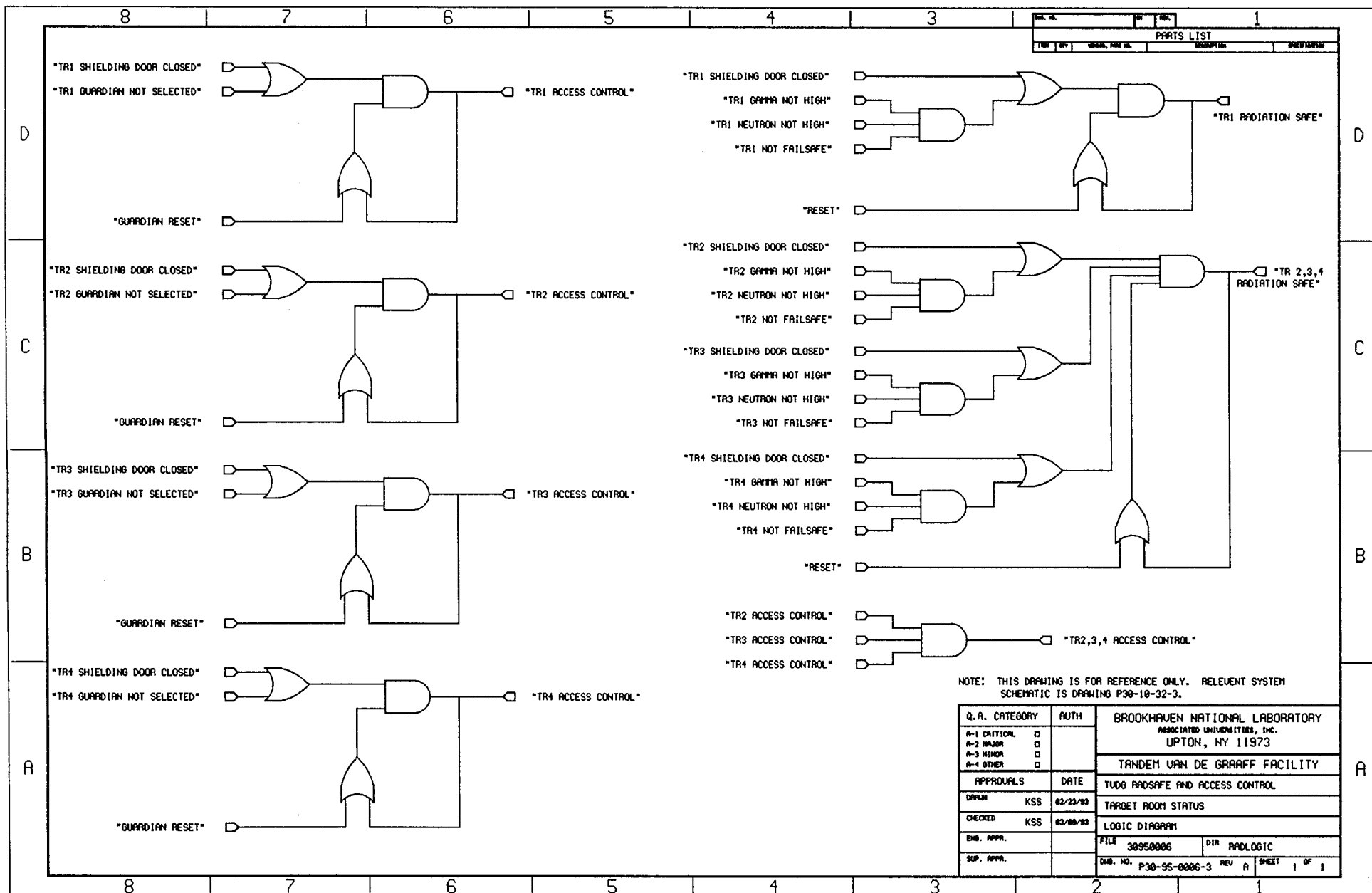
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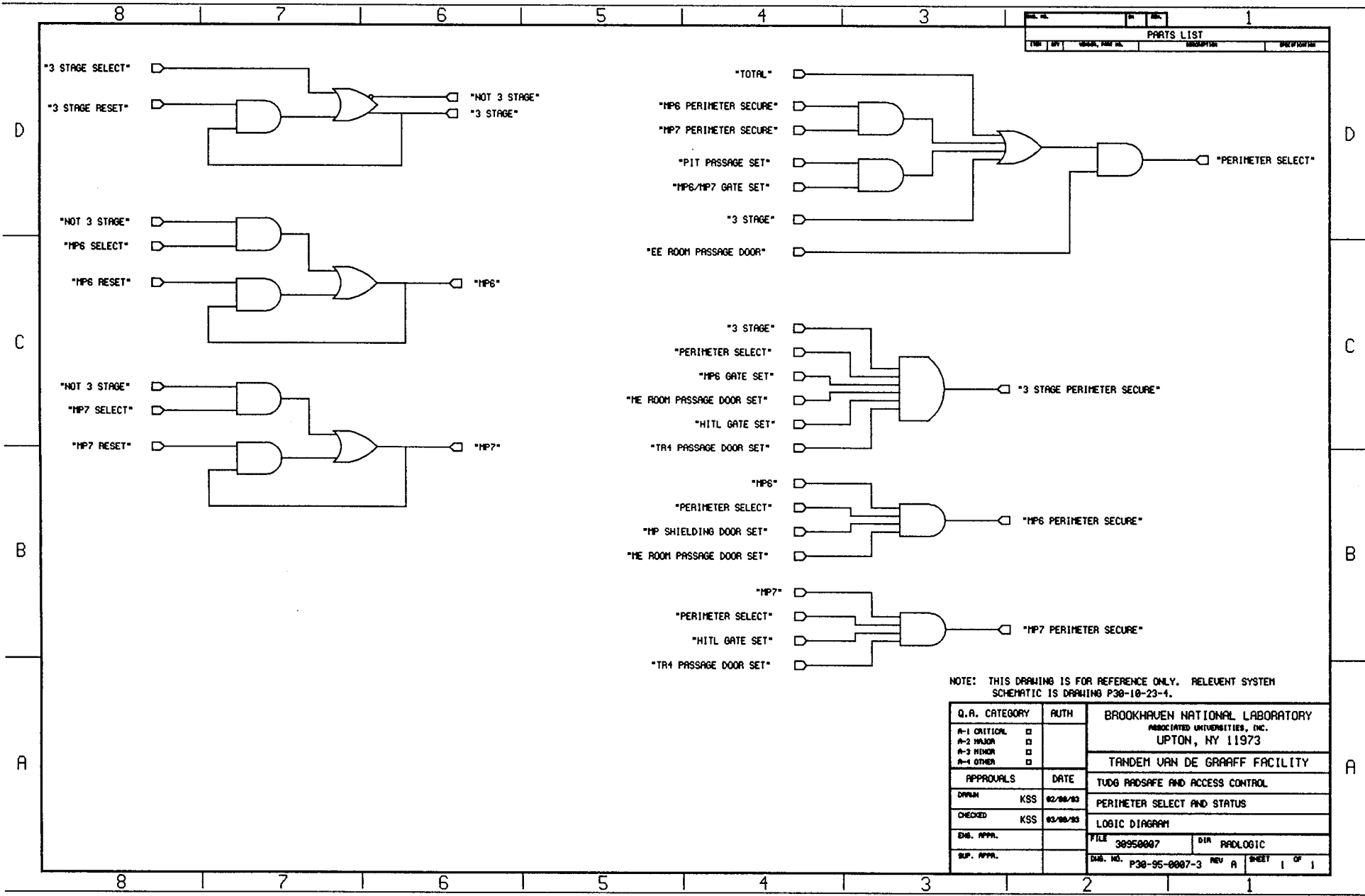
NOTE: THIS DRAWING IS FOR REFERENCE ONLY. RELEVANT SYSTEM SCHEMATIC IS DRAWING P30-10-50-3.

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A-2 MAJOR	<input type="checkbox"/>		
A-3 MINOR	<input type="checkbox"/>		
A-4 OTHER	<input type="checkbox"/>		
APPROVALS		DATE	
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CHECKED	KSS	03/11/83	TARGET ROOM BEAMLINE SAFETY
ENG. APPR.			LOGIC DIAGRAM
SUP. APPR.			FILE 3895-83A RADLOGIC
DWS. NO. P30-95-0003-3		REV A	SHEET 1 OF 2



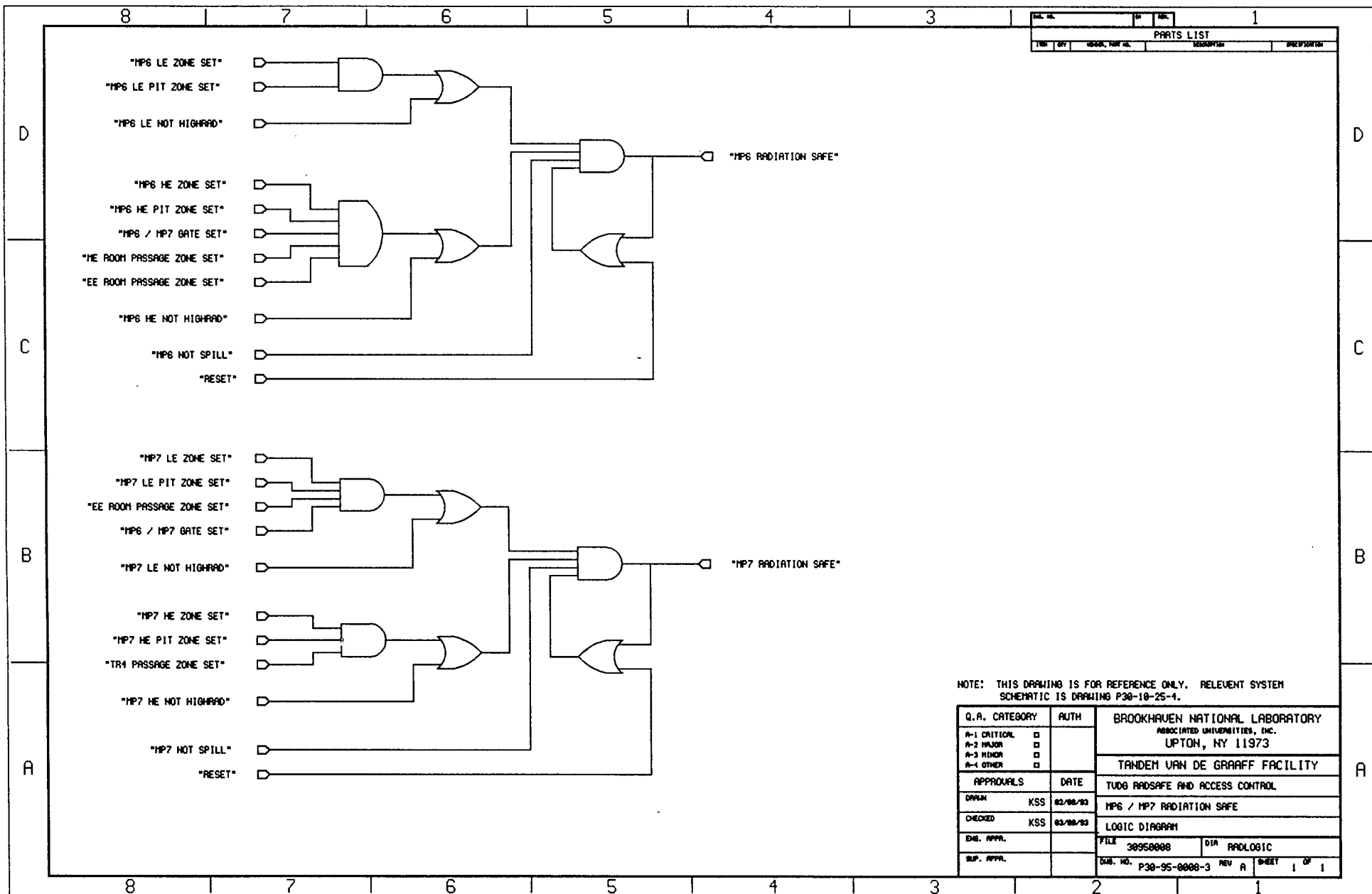






NOTE: THIS DRAWING IS FOR REFERENCE ONLY. RELEVANT SYSTEM SCHEMATIC IS DRAWING P30-10-23-4.

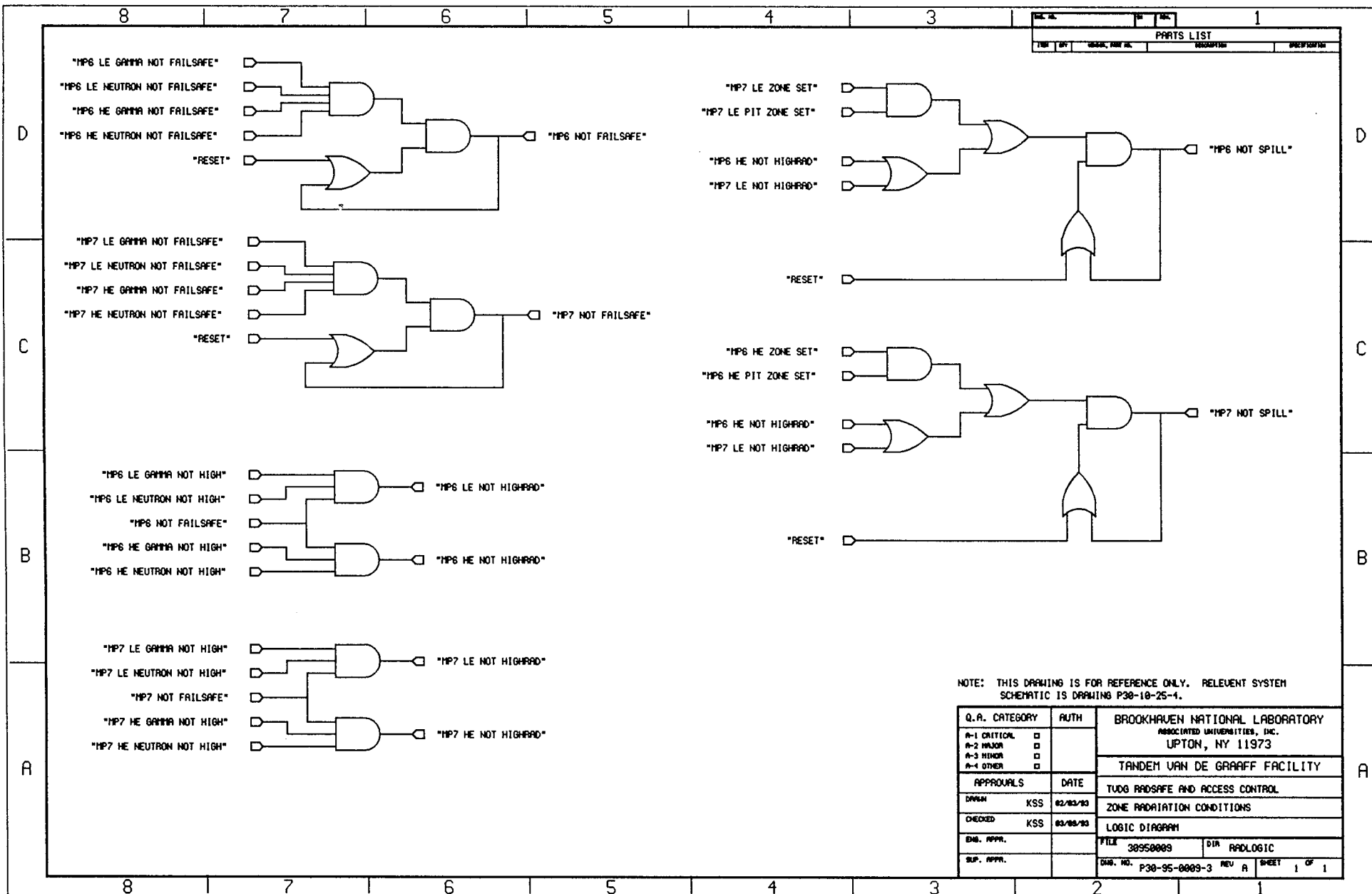
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A-1 CRITICAL		TANDEM VAN DE GRAAFF FACILITY	
A-2 MAJOR		TUDG RADSAFE AND ACCESS CONTROL	
A-3 MINOR		PERIMETER SELECT AND STATUS	
A-4 OTHER		LOGIC DIAGRAM	
APPROVALS	DATE	FILE	DIA
DRAWN	KSS 02/08/93	30950007	RADLOGIC
CHECKED	KSS 03/08/93		
ENG. APPR.			
SUP. APPR.			
		DWG. NO. P30-95-0007-3	REV A SHEET 1 OF 1

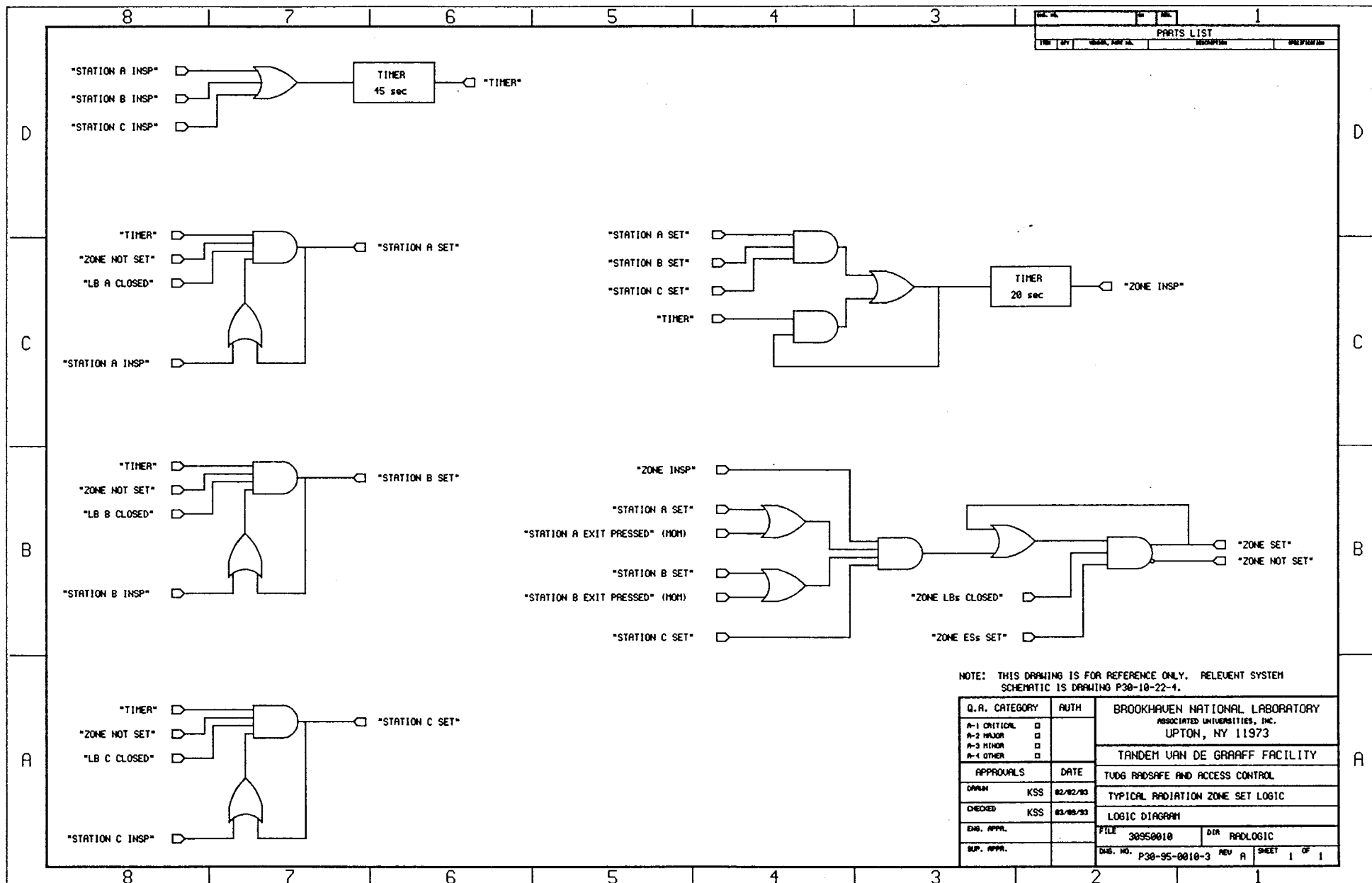


PARTS LIST		DESCRIPTION	QUANTITY
ITEM	QTY	DESCRIPTION	QUANTITY

NOTE: THIS DRAWING IS FOR REFERENCE ONLY. RELEVANT SYSTEM SCHEMATIC IS DRAWING P38-10-25-4.

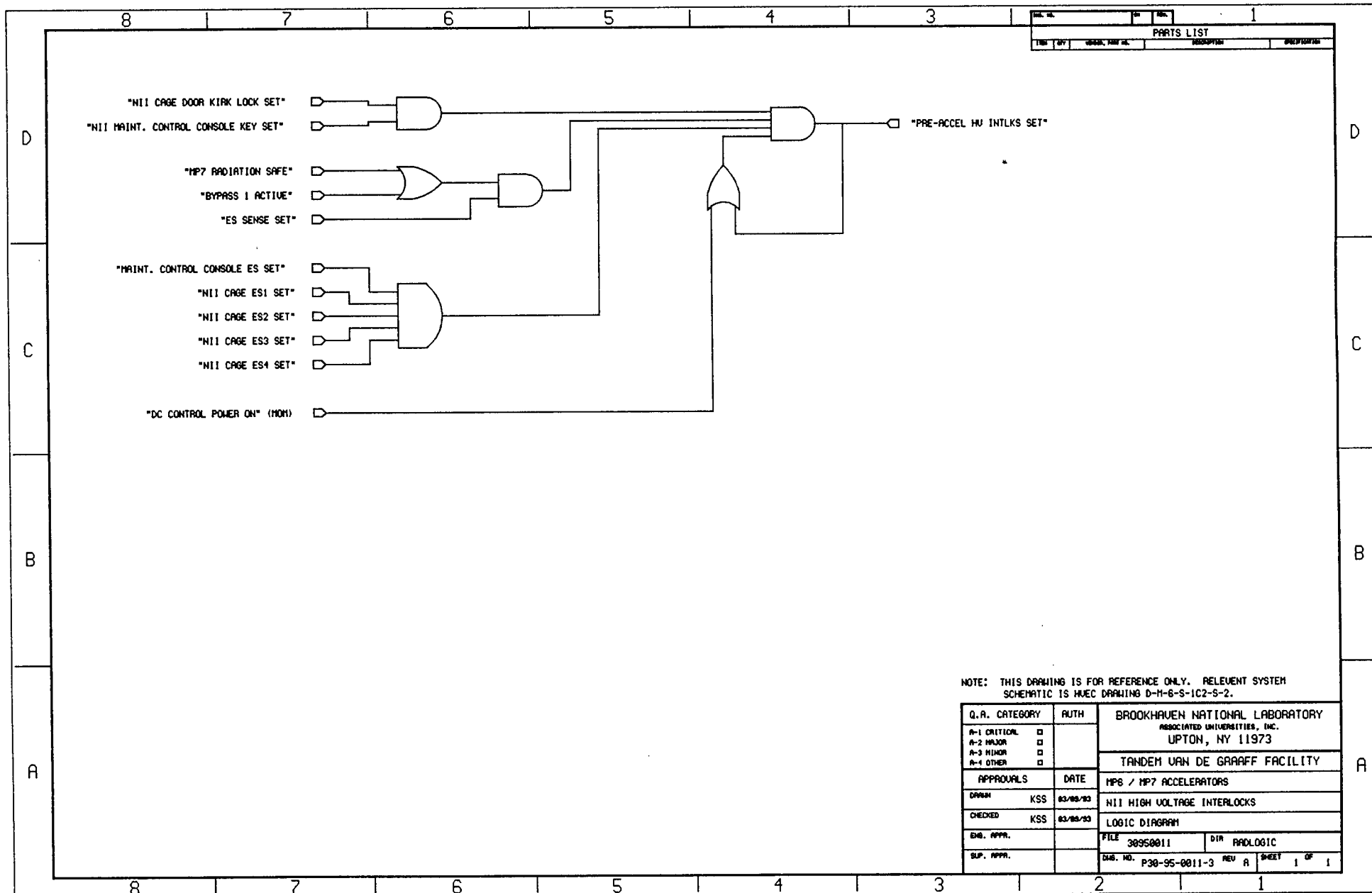
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A-3 MINOR		<input type="checkbox"/>				
A-4 OTHER		<input type="checkbox"/>				
APPROVALS		DATE	TUDS RADSAFE AND ACCESS CONTROL			
DRAWN		KSS	02/08/93			
CHECKED		KSS	03/08/93			
			LOGIC DIAGRAM			
ENG. APPR.			FILE 38950008		DIA RADLOGIC	
SUP. APPR.			Dwg. NO. P38-95-0000-3		REV A	SHEET 1 OF 1





Appendix V

Negative Ion Injector High Voltage Interlock Logic



NOTE: THIS DRAWING IS FOR REFERENCE ONLY. RELEVANT SYSTEM SCHEMATIC IS HUEC DRAWING D-M-6-S-1C2-S-2.

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A-3 MINOR		<input type="checkbox"/>			
A-4 OTHER		<input type="checkbox"/>			
APPROVALS		DATE	MP6 / MP7 ACCELERATORS		
DRAWN		KSS 03/08/93	NII HIGH VOLTAGE INTERLOCKS		
CHECKED		KSS 03/08/93	LOGIC DIAGRAM		
ENG. APPR.			FILE 38950011		DIR RADLOGIC
SUP. APPR.			DWG. NO. P30-95-0011-3 REV A		SHEET 1 OF 1

Appendix VI

Toxicity Analysis of TVDG Insulating Gas Mixture



REPORT OF ANALYSIS

ATTN: Mario Manni
Brookhaven National Lab.
Building 901A

SA#: 533078

Opton: 073

Report Date: 02/28/1992
Received : 02/26/1992
Page : 1

SAMPLE: Sulfur Hexafluoride

LOT# : Sample M
P.O.# : 016626

TEST : Toxicity Test
MOD: SAM 3015

DATE ASSAYED: 02/28/1992

Animal survived the 18-hour exposure and 24-hour observation period. Sulfur Hexafluoride, Lot # Sample M, passes safety test.

phone: 02-27-92
fax:

Scientific Associates, Inc.
by: Paul B. Steingulby

Unless alternate arrangements have been made, samples will be retained for 30 days and raw data for 7 years after report date.

SCIENTIFIC ASSOCIATES INC.



REPORT OF ANALYSIS

ATTN: Mario Manni
Brookhaven National Lab.
Building 901A

Upton, NY 11973

SA#: 533079

Report Date: 02/28/1992
Received : 02/26/1992
Page : 1

SAMPLE: Sulfur Hexafluoride

LOT# : Sample T
P.O.# : 016626

TEST : Toxicity Test
METHOD: SAM 3015
CLAIM :
LIMIT :
RESULT: Date Assayed: 02/28/1992

Animal survived the 18-hour exposure and 24-hour observation period. Sulfur Hexafluoride, Lot # Sample T, passes safety test.

phone: 02-27-92
fax:

Scientific Associates, Inc.
by: Paul B. Steingraber

Unless alternate arrangements have been made, samples will be retained for 30 days and raw data for 7 years after report date.

Results of Analysis

Concentration, Per Cent by Volume

ConstituentsCylinder # 4229

Nitrogen	43.2
Oxygen	5.4
Argon	0.20
Carbon Dioxide	4.8
Hydrogen	ND 0.0004
Helium	ND 0.0004
Sulfur Hexafluoride	46.4

ND = None detected, followed by the limit of detection.

Entered in PERM
2/18/92 @

Two samples of SF₆ mix were sent to Scientific Associates, St. Louis, MO for toxicology tests on mice. Mice were exposed to the 75% gas mixture, 25% O₂ for 18 hour exposures in a sealed vessel, and then observed for an additional 24 hours. The final report from Scientific Associates states that the mice survived the tests and that the samples passed the safety tests as not being toxic.

This test is the type used by the major manufacturer of SF₆ in the U.S.

Cylinder size was 2250 cc.

The samples were produced as follows:

145 PSIG of tank gas containing SF₆, N₂, CO₂, O₂ from TVDG was introduced into a sample cylinder containing 1 atmosphere of air. This was diluted with 145 PSIG of N₂ to reduce the CO₂ percentage of the sample. This was sample "T".

The second sample consisted of 69 PSIG of SF₆, 7.7 PSIG of CO₂, 243.3 PSIG of N₂. This simulated the mix of sample "T". This sample was tagged "M".

Appendix VII

Air Activation by TVDG Beams

**RADIOLOGICAL ASSESSMENT INFORMATION- AIR ACTIVATION
TANDEM VAN DE GRAAFF FACILITY**

1. Location of Potential Source

The potential source is activation of air by neutrons produced by stopping of the beam from the Tandem Van de Graaff accelerators, located in Building 901A. The primary location of neutron production would be in the Accelerator Room or in the Target Rooms.

2. Street Address

Building 901A is located at 59 Cornell Avenue.

3. Latitude and Longitude of Release Point

The primary release point is a ventilation stack located in the east exterior stairwell of Building 901A at N 100,900 E 100,500. (See drawing #21001.)

4. Description of Air Handling Device

The primary release point is the exhaust stack for the building ventilation system. The stack has a rectangular profile. As noted below, the top of the stack is below the roof of the building. Additional information can be obtained from Mario Manni (x4546) or Jane Throwe (x2585).

Elevations

Stack	93'
Ground	83'
Roof	96'

Stack dimensions 40"x52"

Exit velocity of air (2080ft³/min / 14.4ft²) = 144 ft/min

Temperature of exit air Ambient

5. Description of the Process that Generates Radioactive Emissions

Neutrons generated in stopping accelerator beams may activate atoms in the room air. Neutrons are generated primarily by high energy, high intensity proton and deuteron beams. Use of such beams within the facility is rare.

6. Description of Control Technology and Efficiency of This Device

No control technology is in use.

7. Identification and Quantification of Radionuclides Being Released

See attached calculation and table.

8. Restrictions to Facility Operations

Currently there are no restrictions to facility operations. However, use of high energy, high intensity proton and deuteron beams is not typical of facility operation.

Air Activation Calculation

Purpose: To determine whether the concentration of activated isotopes released through the building ventilation exhaust is large enough to require air emissions permits.

References:

1. Accelerator Health Physics, H. Wade Patterson and Ralph H. Thomas.
2. A. Rindi and S. Charalambus, Nuclear Instruments and Methods 47, 1967, 227-232.

Method of calculation:

A worst case estimate of an upper limit for the activity released will be calculated.

For a given nuclide, the number of atoms N in the room at any time is given by solving

$$\frac{dN}{dt} = \left(\frac{\partial N}{\partial t}\right)_{\text{decay}} + \left(\frac{\partial N}{\partial t}\right)_{\text{activation}} + \left(\frac{\partial N}{\partial t}\right)_{\text{ventilation}}$$

where

$$\left(\frac{\partial N}{\partial t}\right)_{\text{decay}} = -N\lambda$$

λ values come from Table 1, Reference 2 or Table 7.1V, Reference 1.

$$\left(\frac{\partial N}{\partial t}\right)_{\text{activation}} = \phi \sigma_{\text{activation}} N_{\text{target}}$$

ϕ	= neutron flux
$\sigma_{\text{activation}}$	= production cross section from same tables
N_{target}	= number of target atoms in room air

and

$$\left(\frac{\partial N}{\partial t}\right)_{\text{ventilation}} = -\frac{ND}{V}$$

with D	= ventilation rate
V	= volume

so that the time for one air exchange is given by $\frac{V}{D}$.

The solution for the activity removed by ventilation rather than by decay is then

$$\left| \lambda \left(\frac{\partial N}{\partial t} \right)_{\text{ventilation}} \right| = \left(\frac{D}{V} \right) \left(\frac{\lambda}{\lambda_{\text{eff}}} \right) \phi \sigma_{\text{activation}} N_{\text{target}} (1 - e^{-\lambda_{\text{eff}} t})$$

with

$$\lambda_{\text{eff}} = \lambda + \frac{D}{V}$$

The final term in parentheses can be replaced by one as an upper limit.

The time for one air exchange in the accelerator room is approximately 2 hours. Therefore, D/V is $1.4 \times 10^{-4}/\text{s}$.

The number of target atoms is calculated based on a 160' flight path (half the length of the accelerator room).

The upper limit for the neutron flux (for 1 μamp of 28 MeV deuterons) is estimated to be $1 \times 10^{11}/\text{s}$ based on Figure 3.40 of Reference 1.

Isotopes with halflife less than ten seconds are not included, because they undergo significant decay before reaching the outlet of the exhaust stack.

For some of the reactions the actual cross-sections for the energy distribution of neutrons produced at the Tandem should be much less than the values indicated in the table. Because the calculated levels do not indicate a need for either permits or monitoring, no attempt has been made to find more realistic values.

Total output for one year is estimated by assuming that the deuteron beam mentioned above operates for forty hours. This beam is difficult to maintain and is generally used as a worst case to test shielding effectiveness. During the past five years annual operation of this beam has been less than half of that estimate. Most operation of the accelerator is with heavier ions or at lower beam current or energy. Therefore, production by all other operation has been neglected by comparison.

UPPER LIMITS FOR RELEASE RATES

Radio-nuclide	Halflife (λ (s ⁻¹))	λ_{eff}	λ/λ_{eff}	Parent element	N_{target} ($\times 10^{22}/cm^2$)	Cross- section (mb)	Activity released ($\mu Ci/s$)	Maximum Annual Release (mCi)
³ H	12.2 y (1.8×10^{-9})	1.4×10^{-4}	1.3×10^{-5}	N	9.9	30	1.9×10^{-5}	2.7×10^{-3}
				O	3.0	30		
⁷ Be	53 d (1.5×10^{-7})	1.4×10^{-4}	1.1×10^{-3}	N	9.9	10	5.4×10^{-4}	7.8×10^{-2}
				O	3.0	10		
⁴¹ Ar	1.8 h (1.1×10^{-4})	2.5×10^{-4}	.44	⁴⁰ Ar	.17	610	1.7×10^{-1}	24
¹¹ C	20.5 min (5.6×10^{-4})	7.0×10^{-4}	.80	N	9.9	20	7.8×10^{-1}	110
				O	3.0	20		
¹³ N	10 min (1.2×10^{-3})	1.3×10^{-3}	.89	N	9.9	30	1.1	160
				O	3.0	10		
¹⁵ O	2.1 min (5.5×10^{-3})	5.6×10^{-3}	.98	O	3.0	60	6.6×10^{-1}	95
¹⁴ O	74 sec (9.4×10^{-3})	9.5×10^{-3}	.99	O	3.0	5	5.6×10^{-2}	8

Appendix VIII

Hazard Classification for the Tandem Van de Graaff Facility

**HAZARD CLASSIFICATION
FOR THE
TANDEM VAN DE GRAAFF FACILITY**

The Tandem Van de Graaff Facility is proposing a "low" hazard classification accelerator facility based on the following information.

I. Definition of the Facility

For the purpose of Order 5480.25, the Tandem Van de Graaff Facility should be considered to include the following areas:

1. Accelerator Rooms
2. Control Room
3. Target Rooms 1,2 and 4
4. Target Room 3, when it is in use as a target room for the Tandem accelerators or for projects related to the accelerators
5. The Mechanical Equipment Room
6. The TTB tunnel

The attached color picture of Building 901A shows areas 1-5. The picture was made prior to construction of the TTB tunnel. The connection of the building to the TTB tunnel is shown in the second diagram. The color picture of the accelerator complex shows the TTB tunnel in yellow.

The hazard classification covers the operation of the Tandem accelerators and all associated projects, experiments and uses of the beam within the Tandem Facility, including transport of the beam through the TTB tunnel. It does not cover acceleration and use of the beam by the synchrotrons or operation of the synchrotrons.

Target Room 3 is currently used for a project unrelated to the Tandem accelerators. That project is undergoing its own ES&H review, and is not included in the current hazard classification request. However, if Target Room 3 is again used as a target room, it would be covered by the current hazard classification, since conditions of use would be virtually identical to those in the other target rooms.

II. Access Controls for Secured Areas

The Tandem Facility has a varied capability for producing radiation depending on the type of ion being accelerated. Light ion beams are capable of producing High Radiation Areas, while heavier ions produce no appreciable radiation fields. The Radiation Safety and Access Control System has

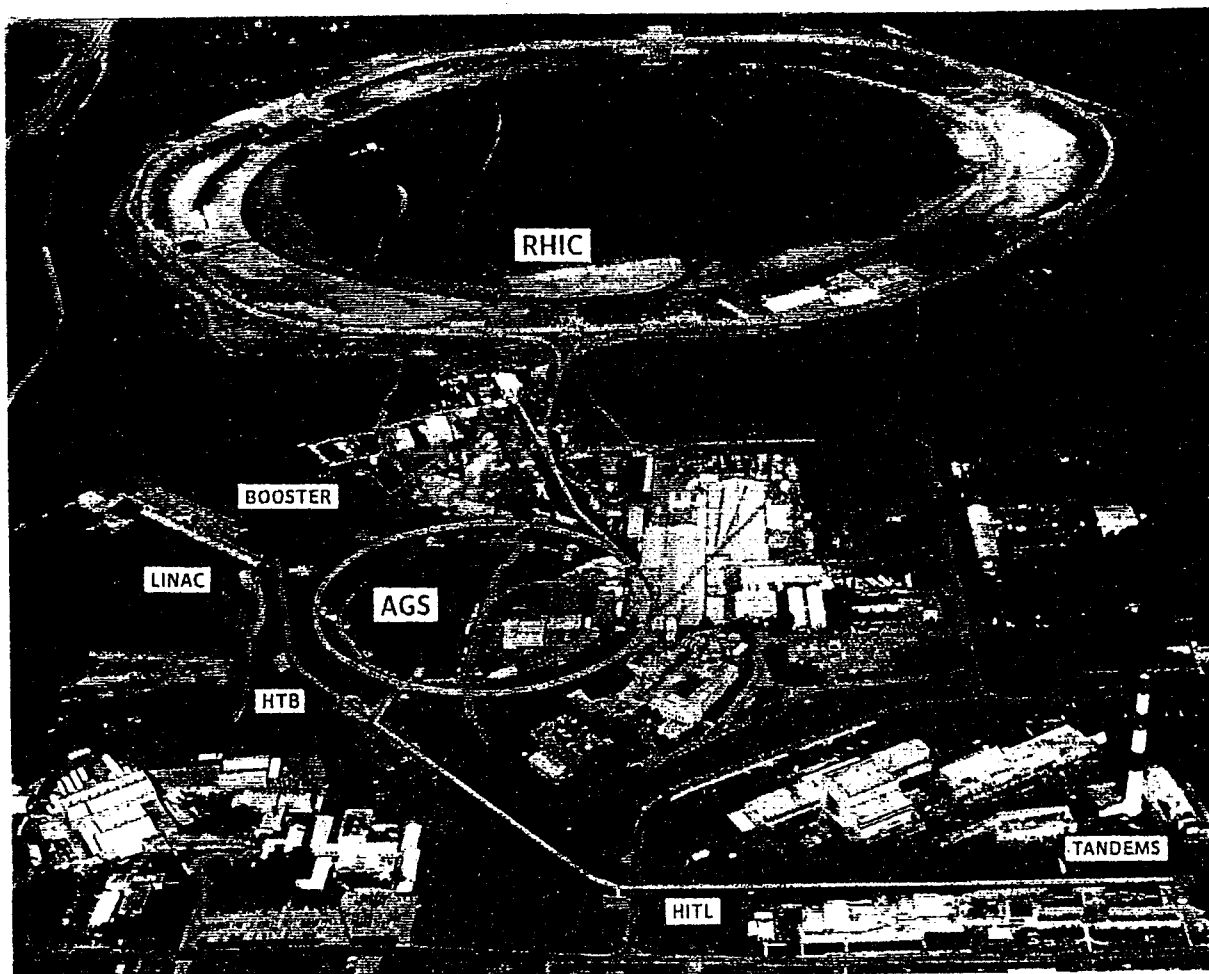
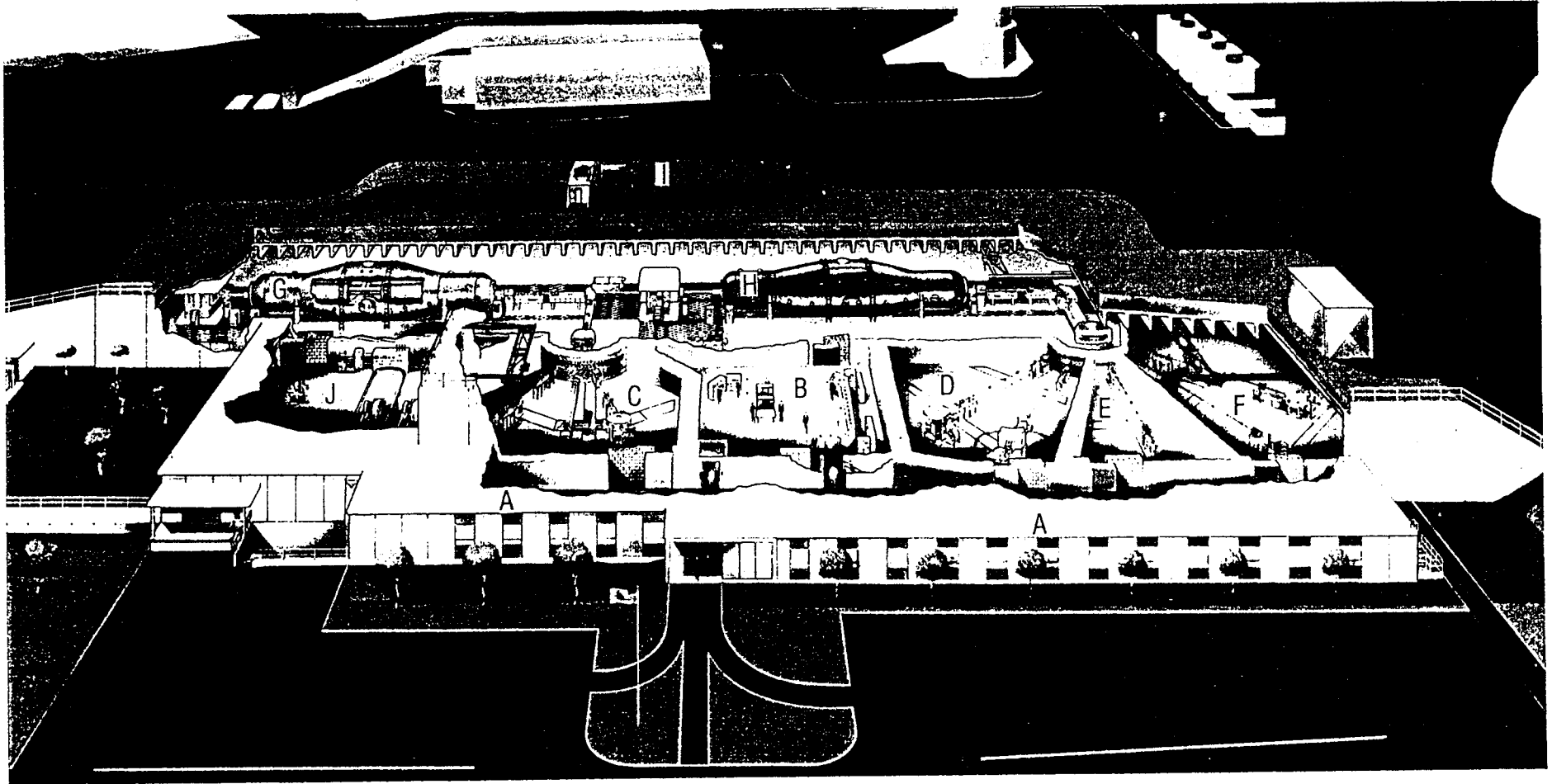


Figure 3-1

Aerial view of the Tandem/TTB complex and related structures. The TTB tunnel is labeled with the names of its components, HITL and HTB.

Tandem Van de Graaff Facility-Building 901A



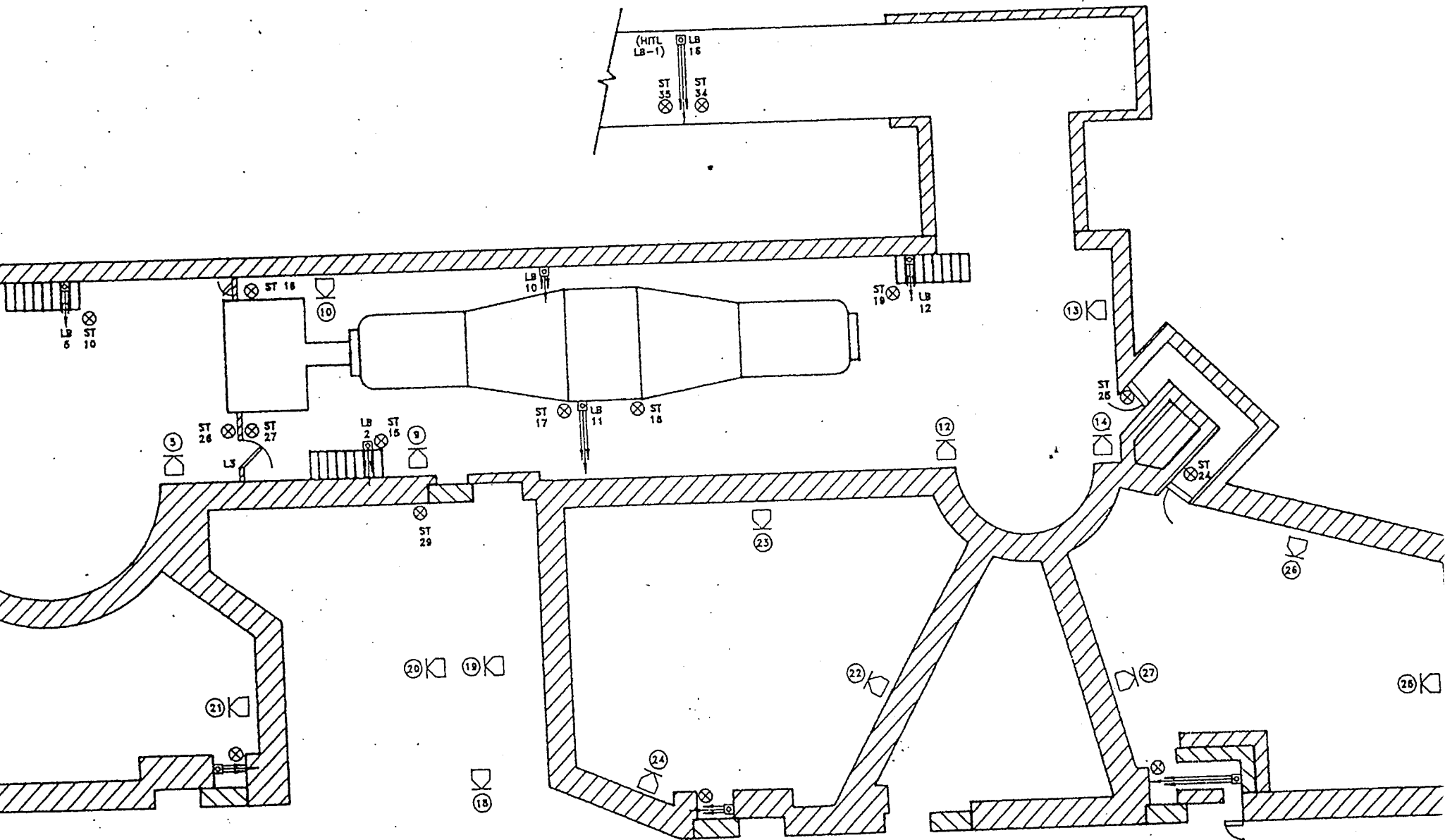
A) Offices & Labs
B) Control Room
C) Target Room 1
D) Target Room 2
E) Target Room 3

F) Target Room 4
G) MP6 Accelerator
H) MP7 Accelerator
I) Insulating Gas Storage
J) Mechanical Equipment (ME) Room

Not Shown:

- 1) Building Equipment (BE) Room
- 2) Electrical Equipment (EE) Room
- 3) Modular Additions

Figure 3-2



been designed to allow the required access to accelerator equipment and beamlines while maintaining radiation safety. Accelerator and Target Rooms do not necessarily become exclusion zones while beam is present. However, access is controlled by a combination of safety systems and administrative controls. A detailed description of the Access Control System can be found in the Safety Assessment Document for the Tandem Van de Graaff Facility, Section 4.1.1. A brief summary is given here.

Access to secured areas is controlled by

1. Radiation zones

Accelerator and Target Rooms have been divided into a number of radiation zones, which must be searched, secured and interlocked when it is expected that radiation levels within might be above the amber/red setpoint (100 mR/hr or less). If administrative controls are violated so that radiation in an unsecured zone exceeds the setpoint, radiation controlled interlocks cause exclusion of the beam from that zone or shutdown of accelerator functions.

Radiation monitoring for a zone consists of a local controller with associated gamma and neutron probes. Battery backup provides protection in the event of power loss. The local units communicate with the central controller by means of dedicated lines. A computer is used only to log data; it is not part of the interlock system. The system produces a failsafe mode if communication with a local controller is broken, if the gamma reading falls below a threshold or if the unit has no power. A master display in the Control Room informs the operators of the status of the system.

2. Perimeter

An interlocked Faraday cup (beamstop) prevents the acceleration of ions unless a machine perimeter is established. Once an active perimeter is established, entry through any access point other than the door from the Control Room to the Accelerator Room is administratively prohibited. If entry is made in violation of this prohibition, interlocks cause insertion of beamstops. The system is relay based and enters a failsafe mode on loss of power. A master display panel in the Control Room informs the operators of the status of the system.

3. Other controls

Additional controls, such as locks, active warning signs and administrative controls also prevent access to secured areas.

III. Definition of Secured Areas

The following areas are secured:

- A. The Accelerator Rooms
- B. Target Rooms 1, 2 and 4
- C. Target Room 3, when it is in use as a target room for the Tandem accelerators
- D. The TTB tunnel

A description of the control of access points for each area is given below. Where a shielding door is present on the building diagram, there is also an additional sliding door outside of it. Because radiological conditions do not always require closing the shielding door, the sliding door is treated as the access point.

A. The Accelerator Rooms

Although designated as two rooms on the building drawing, these are physically a single room with a pit area beneath.

- 1. The sliding door from the Control Room is posted with signs requiring operator permission for entry. The door is within clear view of the operator at the console.
- 2. All other access points to the Accelerator Rooms have one or more of the following controls:
 - a. kept locked
 - b. located within a secured area with access points to that area locked
 - c. interlocked as part of the machine perimeter.

B. Target Rooms 1, 2 and 4

- 1. Sliding doors from the hallway - Removal of beamstop to allow beam into a target room activates a warning sign in the hallway next to the sliding door.
- 2. When ion species, energy and maximum available current could produce radiation in excess of the red/amber setpoint within a target room, administrative controls require the room to be placed in Target Room Guardian mode. In this mode the Faraday cups that must be extracted to allow beam to enter the target room are interlocked to the shielding door.

3. Wooden door from the hallway to Target Room 4
- Locked. Also interlocked when the Target Room is in Target Room Guardian mode.
- C. Target Room 3, when it is in use as a target room for the Tandem accelerators - Access controls would be the same as for other target rooms.
- D. The TTB tunnel
 1. Doorways from three power supply houses located along the tunnel - Locked.

The tunnel also has escape hatches, but these have no exterior knobs or pulls, and thus are not access points.

IV. Maximum radiation levels produced by the facility.

- A. The radiation level that could exist for normal operation within 1 meter of the beam is greater than 100 mrem per hour; therefore, the facility hazard class is greater than a "routinely accepted hazard."
- B. Maximum Credible Accident - Radiation - Onsite

The MP6 accelerator is currently out of service for longterm maintenance and upgrade, and shielding effectiveness studies will be required when it is put back into service. Data for the MP7 accelerator will be used to produce an estimate of possible dose rates. It should be pointed out that during shielding effectiveness studies, the MP7 accelerator generates 1 microamp of 25.5 Mev deuterons. It requires operational effort to generate and maintain this beam; sometimes it has become necessary to reduce current and to scale readings upward. It is therefore not credible that this beam could be accidentally generated for one hour. However, the radiation dose rate from this beam can be used to establish an upper bound for the dose rate for the maximum credible accident.

Shielding effectiveness studies have shown that the maximum radiation dose rate that can be generated outside of secured areas with the shielding doors closed is less than 100 mRem/hr. Therefore, it is not possible for an individual to receive a dose in excess of 25 Rem in one hour outside of secured areas as long as the shielding doors are closed.

Tandem beams vary greatly in their potential to produce radiation. The ability of a beam to produce radiation increases with increasing beam energy or intensity or with decreasing ion mass. Therefore, the procedures and safeguards that protect individuals from radiation exposure depend on the beam being generated. Many beams that are produced are not capable of generating radiation above the amber/red setpoint (less than 100 mRem/hr), even within the secured area. During acceleration and use of these beams, shielding doors between secured and unsecured areas remain open to allow maximum access to equipment. For beams capable of generating greater than 100 mRem/hr within the secured area, shielding doors are closed and interlocked to prevent access. To determine whether the maximum dose outside of secured areas could exceed 25 Rem in one hour for the maximum credible accident, it is sufficient to determine whether or not it is credible that a beam capable of producing 25 Rem in one hour at the sliding door boundary of a secured area could accidentally be maintained in an area whose shielding door was open.

Shielding doors are located adjacent to each accelerator in the Accelerator Rooms and at the hallway entrance to each Target Room. The Accelerator Rooms and Target Rooms will be discussed separately.

1. Accelerator Rooms

Administrative controls and radiation controlled interlocks prevent the shielding doors from remaining open when high dose rates are produced in the Accelerator Rooms. Even if these redundant precautions somehow failed, the dose rate outside of the secured area would not exceed 25 Rem/hr. Upper limits will now be established for two cases.

During shielding effectiveness studies, operation of the MP7 accelerator produces a dose rate of less than 50 mRem/hr at the low energy end of the machine, which is adjacent to the Control Room shielding door. Therefore, the dose rate produced by an accelerator at the location of its respective shielding door is much less than 25 Rem/hr.

Also to be considered is the maximum dose rate produced by operation of the MP6 accelerator with the Control Room shielding door (adjacent to MP7) open. The maximum dose rate recorded within the

accelerator room during shielding effectiveness studies was approximately 70 Rem/hr at 3 ft from the stopping location at about 20°. The Control Room sliding door is greater than 30 ft from any part of the MP6 beamline. Therefore, the dose rate outside the door should be less than 700 mRem/hr. It should also be noted that the configuration of the shielding at the doorway provides considerable protection from radiation from MP6, even if the shielding door were open. The actual dose rate should be much less than the number above. However, even the unrealistic upper limit given here is considerably less than the 25 Rem in one hour limit for a low hazard facility.

2. Target Rooms

Shielding effectiveness studies within target rooms indicate that dose rates can reach 200 Rem/hr approximately 3 feet from a stopping location. However, the six foot thickness of the shielding wall prevents a beamline from being located less than 10 ft from the hallway sliding door. No existing beamline has a location and an inclination that would allow 25 Rem/hr to be generated at the sliding door. However, it might be possible to construct a beamline that could generate in excess of 25 Rem/hr at the sliding door with the shielding door open. Therefore, precautions that prevent the shielding door from being left open inappropriately will be discussed.

- a. Interlocks controlled by the radiation monitoring system described in Section II.1 would shut down machine functions if radiation exceeded the amber/red setpoint (maximum 100 mRem/hr).
- b. Procedures require interlocking of the shielding door when it is expected that the amber/red setpoint could be exceeded. The computer program that gives operators settings and indications for generating a desired beam gives repeated warnings if significant radiation could be produced by that beam. If these warnings appear, the target room must either be immediately placed in Target Room Guardian mode, with the shielding door interlocked, or it must be surveyed with the intensity at maximum to determine the need to place it in that mode. Any error would be found at the commencement

of the survey, limiting the time involved to .1 hours or less.

- c. In order for the wrong ion species to enter the accelerator with significant intensity, one wrong setting and two wrong indications are required. In order for it to reach a target room, additional wrong settings would be necessary. It is not credible that this number of errors could occur unless the operator had input the wrong ion species into the computer program, and thus generated the settings and indications for the wrong beam. If that were the case, the program would also generate appropriate radiation warnings for that beam. The operator would either act in accordance with the radiation warnings or discover the input error.

Using the settings for a higher mass beam to accidentally bring a lower mass beam into a target room would result in decreased transmission. The intensity required to generate high radiation fields would not be produced.

C. Potential for Offsite Exposure

Building 901A is located approximately one mile from the site boundary. If exposure to prompt radiation directly outside the secured area were 25 Rem/hr, with the boundary of the secured area being less than 100 ft from the area where radiation is being generated, then the site boundary should experience a dose no greater than 10 mRem/hr (down by a factor of at least 50^2). In fact, the maximum dose rate outside of a secured area is considerably less than 25 Rem in one hour, as described above. Also, there would be considerable attenuation between the boundary of the secured area and the site boundary. However, it is evident that if the portion of the facility within building 901A does not exceed the 25 rem in one hour criteria outside of the secured area, then the dose due to prompt radiation for anyone at the site boundary is considerably less than the dose of 1 Rem in one hour that is the upper bound for a low hazard facility.

The TTB tunnel approaches somewhat closer to the site boundary, but shielding effectiveness studies have shown that prompt radiation outside the tunnel can produce dose rates no higher than 100 mRem/hr, even within the associated support buildings. Therefore,

with shielding intact, the TTB tunnel cannot produce a dose rate of 1 Rem in one hour at the site boundary.

V. Radioactive material permitted in the facility.

Sealed sources present in the facility consist of two Cs¹³⁷ sources of less than 4 Ci each and small check sources used for calibration purposes.

During the majority of operating time the beams produced do not have sufficient energy per nucleon to cause activation. However, the lower mass beams can activate beamline components and targets. The induced activity is extremely low level. Operations staff who may enter the accelerator and target rooms immediately after the beam has been excluded have not shown any detectable radiation exposure on their film badges.

Based on the radioactive material present, the facility is classified as a non-nuclear radiological facility in accordance with DOE-STD-1207-92.

VI. Hazardous chemical inventory.

A. Flammable liquids are stored in a flammable storage cabinet, located in the Mechanical Equipment Room. Small quantities of flammable liquids for day-to-day use (typically in containers holding less than 500 ml each) are kept outside of the cabinet. The quantity present both in and out of storage is consistent with fire safety recommendations. The hazard associated with the flammable liquids should be considered routinely accepted.

B. In addition to the insulating gas, approximately 20 cylinders of nonflammable compressed gases (primarily nitrogen, oxygen, helium and argon) are stored in the Mechanical Equipment Room or are in use throughout the facility. The hazard associated with nonflammable compressed gases should be considered routinely accepted.

C. There is occasional use of flammable gas within the facility. The gas is not stored within the facility when not in use. Any system containing more than 10 scf of flammable gas must undergo review.

VII. Unusual hazards

The following hazards are present in the facility, but are expected to have no more than minor on-site and negligible off-site impacts to people or the environment.

1. Gas asphyxiation
2. Confined spaces
3. High pressures
4. Electrical hazards
5. Stray magnetic fields.

These hazards are controlled by measures such as monitoring, interlocking, physical barriers, postings, training and written procedures.

A. Gas Asphyxiation

A detailed description of the insulating gas system can be found in Section 4.1.2 of the Facility SAD. When in operation, each accelerator vessel contains 11250 ft³ of insulating gas mixture at a pressure of less than 300 psig. The maximum credible accident would be the rupture of a viewport on an accelerator vessel, allowing the release of the gas from one vessel into the accelerator room (room volume 280,000 ft³). It is estimated that the release time would be about 30-45 minutes. Any rapid release would be accompanied by a loud noise and by substantial mixing of the gas with room air. In the event of a rapid release, the noise would be sufficient to alert anyone in the room to the hazard. For the purpose of defining the maximum credible accident, it will be assumed that the operators do not operate any part of the gas handling system in an attempt to save the tank gas. Then the insulating gas would be released into the accelerator room and removed via a vent stack driven either by normal building ventilation or by a purge fan activated by operators. Calculations indicate that in most of the room oxygen concentrations would be sufficient to sustain life, however, there might be some areas with concentration low enough to be lethal. It is most likely that these areas would be in the pit under the accelerators or in the vicinity of the breach. It should be emphasized that the insulating gas is present in an accelerator only when the machine is in operation, while maintenance activities that require the presence of large numbers of personnel in the Accelerator Room are normally performed while the accelerator is out of service. It would be rare for more than six individuals to be in the Accelerator Room while an accelerator was operating. Of those six,

perhaps two might be at locations where asphyxiation was a threat. It is likely that even these two would have sufficient warning to escape from the room without sustaining any injury, however, two fatalities can be used as an upper limit.

In the event of a slow leak, the gas would be expected to be removed from the room by normal building ventilation without reaching lethal concentrations. Also, degradation of accelerator performance and a drop in pressure would alert the accelerator operators to the problem.

In the event of a power failure, the Accelerator Room is unoccupied except that one or two operators might enter the room to turn off equipment.

The risk of asphyxiation is limited to the secured areas listed in Section III. The ventilation system does not circulate the gas from the Accelerator Rooms through other areas of the building. In any case, the concentration of insulating gas in the exhaust from the Accelerator Rooms is not expected to reach concentrations that are hazardous. Thus other building inhabitants and those outside of the building are not at risk.

The estimates above do not consider the response of both oxygen and halogen monitors located in the Accelerator Rooms to alert personnel to any release. With these systems providing an alarm, it is even more unlikely that anyone would be asphyxiated.

B. Confined Spaces

The Tandem Facility includes two accelerator vessels that are confined spaces. The vessels are within a secured area (the Accelerator Rooms) and entry to the vessels poses no risk to those outside that area. A primary concern to those within the vessel is the threat of asphyxiation if insulating gas were to be released into the vessel while it was occupied. Protection against this occurrence includes double block and bleed or physical disconnection of gas transfer lines entering the vessel, interlocking or lockout/tagout to prevent inadvertent opening or closing of valves, written checklists for tank entry, continuous forced ventilation, and monitoring of both oxygen and halogen levels within the vessels while they are occupied. High voltages and moving machinery are locked out whenever possible when the tanks are occupied.

Appendix IX

Building 901A Shielding Effectiveness Studies

**BUILDING 901A
SHIELDING EFFECTIVENESS STUDIES
7/92 AND 4/94
TANDEM VAN de GRAAFF FACILITY**

8/94
J. Benjamin
C. Carlson
J. Throwe
F. Zafonte

Studies were conducted with a 25.5 Mev deuteron beam according to the Tandem Van de Graaff Beam Fault Measurement Procedure contained in Appendix A. Measurements were made at currents of 1 μ A and 500 nA, as higher currents could not easily be maintained. It is expected that these approximate worst case conditions for production of radiation. All of the data in this report has been scaled to correspond to a beam current of 1 μ A, and background has been subtracted. For conditions where more than one measurement was made with shielding in its current configuration, the worst case number has been reported. The original data for the 1992 measurements is contained in the Tandem Operations and Maintenance Log (Start date 5 May 92, pages 59-64). For the 1994 studies, the data is available compiled as "Fault Studies, MP-7 Target Rooms, 2H at 25.5 MeV". Copies of the data can be obtained from the TVDG ES&H Coordinator.

The Radiation Safety and Access Control (Radsafe) System protects those who enter target rooms and the accelerator room. ("Target Room 3" is no longer a target room and is not covered by the Radsafe system.) It is recognized that areas covered by this system have the potential to be Radiation or High Radiation Areas. Measurements taken in these areas appear in shaded blocks in the data tables. In addition, measurement areas are labeled as "controlled" if they are Controlled Areas. Not all Controlled Areas are covered by the Radsafe System.

It should be noted that for most operating conditions the energy per nucleon and the beam current are much lower than for the beam used in these studies. As a result, the typical radiation dose rates during accelerator operation are lower than the rates measured here by orders of magnitude. Therefore, in some areas, postings or other precautions are recommended only for extreme operating conditions, usually triggered by the use of low mass beams.

This fault study complements the HITL/HTB fault study conducted 10/91. The results of that study are described in T. Robinson's memo entitled "HITL/HTB Fault Studies" dated 12/24/91. Copies of that memo are available from the TVDG ES&H Coordinator.

Figure 1 is a map of Building 901A, showing the locations of the various rooms and of the MP-7 accelerator in Accelerator Room 2. More detailed drawings available from the ES&H Coordinator show the locations of the various points along the beamlines where the beam was stopped during the measurements. The MP-6 accelerator in Accelerator Room 1, and Target Rooms 1 and 3 were not included as sources in the study, since they are not currently sources of beam-related radiation. Figure 1 predates the HITL tunnel. Therefore, Figure 2 has been included to show the beginning of the tunnel at the back of Accelerator Room 2.

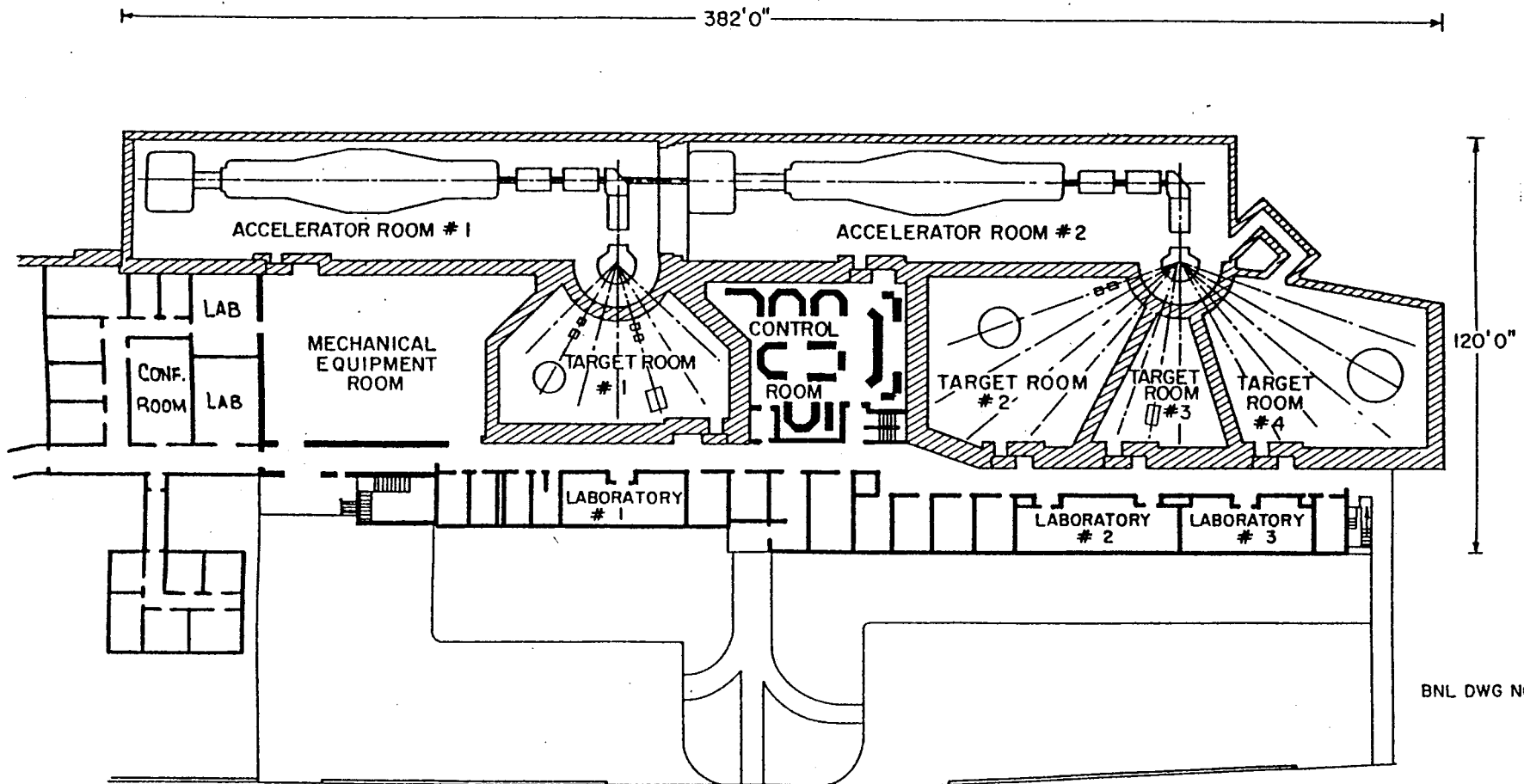
INSTRUMENTS USED

NRC Area Monitors

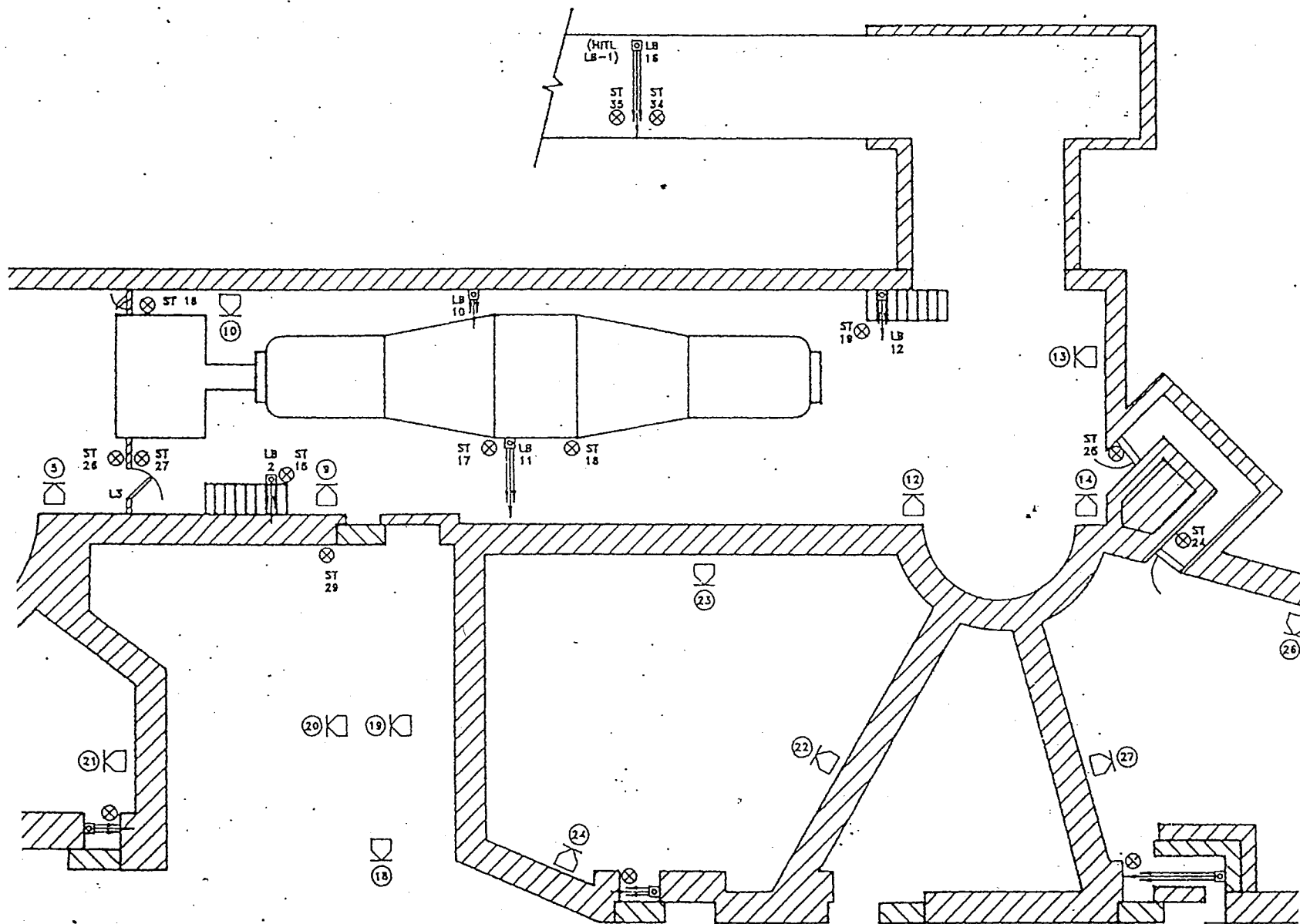
Neutrons

Probe	NP-100
Controller	ADM-610

TANDEM VAN DE GRAAFF FACILITY
BROOKHAVEN NATIONAL LABORATORY



BNL DWG NO.P30-1-25-2B



Gammas

Probe IP-100
Controller ADM-610

Measurements made with the NRC area monitors appear in shaded boxes in the text. These monitors were located in areas covered by the Radsafe System, and the measurements were made primarily to allow correlation with measurements in uncontrolled areas.

Snoopy

For neutrons

μ R Meter

For gammas

RESULTS AND RECOMMENDATIONS

1. With the beam stopped in the Accelerator Room radiological conditions are acceptable in both controlled and uncontrolled areas. No additional shielding or posting is necessary.
2. Stopping the beam in Target Room 2 resulted in measurable radiation in the following areas that are not covered by the Radiation Safety and Access Control System.
 - a. Target Room 3 received up to 7 mR/hr of γ radiation and up to 12 mRem/hr of neutron radiation. The highest readings are measured at the north side of the room when the beam is stopped at the 40 W wall valve. Some shielding is already in place on both sides of the common wall between the rooms. Installation of additional shielding to reduce the measured dose rates would be difficult. The north side of the room contains electronics racks belonging to the Tandem Operations Group; the area is not normally occupied for extended periods. In addition, introduction of low mass, high current beams into the 40 W line is rare. Therefore, additional shielding is not necessary. The south side of Target Room 3 is currently being used by the Advanced Accelerator Group to set up their Cluster Klystron Project. That project will introduce significant radiological concerns that will require posting and related access restrictions likely to be more stringent than those related to the radiation from the 40 W beamline. Therefore, it is appropriate to post the room as a Controlled Area and to provide additional postings only under extreme operating conditions. When lithium or any lighter beam is introduced to the 40 W line, it will be necessary to survey to determine whether part of the room must be posted as a Radiation Area.
 - b. The pipechase in the basement received up to .3mR/hr of γ radiation and up to 1.5 mRem/hr of neutron radiation. A panel with a Controlled Area

posting has been installed to restrict access to the pipechase.

- c. Measurements in the hallway outside the shielding door were up to .055 mR/hr γ radiation and up to .35 mRem/hr neutron radiation. At these dose rates it would require over 50 hours of exposure for an individual to exceed annual Administrative Control Levels for the public. It is highly unlikely that an individual would spend even a fraction of that time in one year in the vicinity of the shielding door. Also, introduction of low mass, high current beams to the beamlines in Target Room 2 is rare. Therefore, additional postings and shielding are not recommended.
3. Stopping the beam in Target Room 4 resulted in radiation in the following areas that are not covered by the Radiation Safety and Access Control System.
- a. Since the study, shielding has been added to decrease dose rates in the hallway outside the emergency wooden door. These rates were 1 mR/hr γ radiation and 3.5 mRem/hr neutron radiation in the latest study. Until the additional shielding can be tested, precautions will be taken when lithium or lighter beams enter the 55 E beamline. Either the hallway will be surveyed and posted as a Controlled Area where necessary, or the Radsafe System will be operated in a mode that results in shutdown of the accelerator if the neutron or γ dose rate within the Target Room exceeds 50 mRem/hr. Since the neutron dose rate in the Target Room was 640 mRem/hr for an equivalent 1 μ A beam, this ensures that the dose rate in the hallway should not exceed .5 mRem/hr if the hallway is not posted.
 - b. The dose rate in Target Room 3 was measured at .2 mR/hr γ radiation. Shielding has already been added to the common wall between the two rooms; addition of new shielding to reduce the measured dose rates would be difficult. Target Room 3 is discussed in 2a above; no additional shielding is required.

Beam Stopped in the Accelerator Room

		STOPPING LOCATION/CONDITION			
MEASUREMENT LOCATION		HE Cup	Object Cup	Image Cup	Analyzer Off
Control Room	γ (mR/hr)	background		background	
	n (mRem/hr)	background		background	
Target Room 2 (controlled)	γ (mR/hr)	0.014	0.026	0.135	
	n (mRem/hr)	background	background	0.7	
Target Room 3 (controlled)	γ (mR/hr)	0.014	0.030	0.070	
	n (mRem/hr)	background	background	background	
Target Room 4 (controlled)	γ (mR/hr)	0.014	0.070	0.190	
	n (mRem/hr)	background	background	0.25	
HITL (controlled)	γ (mR/hr)	0.014	0.044	0.034	0.20
	n (mRem/hr)	background	0.3	background	2
Roof	γ (mR/hr)	background	background	background	background
	n (mRem/hr)	background	background	background	background

Beam Stopped in the Accelerator Room

The following data from the 1992 study was taken 3 feet from the Object Cup at approximately 0°. It may be correlated with the data of other tables to determine how radiation levels on the NRC area monitors correspond to levels in other areas.

1992	STOPPING LOCATION/CONDITION			
	HE Cup	Object Cup	Image Cup	Analyzer Off
γ (mR/hr)	52.6	1840	144	60
n (mRem/hr)	703	68000	3680	1200

The following data from the 1994 study can also be used to determine correspondence between radiation levels. The readings at the HE end correspond approximately to the data from 1992 that is in the table above. More information on placement of the monitors is included in the original data.

1994		STOPPING LOCATION/CONDITION		
MEASUREMENT LOCATION		HE Cup	Object Cup	Image Cup
LE End (controlled)	γ (mR/hr)	1.2	1.3	1.2
	n (mRem/hr)	6	11.25	8.0
HE End (controlled)	γ (mR/hr)	46	1170	81
	n (mRem/hr)	750	47000	3100

Beam stopped in Target Room 2

		STOPPING LOCATION/CONDITION			
MEASUREMENT LOCATION		60W Beam Dump	60W Wall valve	40W Faraday Cup	40W Upstream Valve
Roof	γ (mR/hr)	background	background	background	
	n (mRem/hr)	background	background	background	
Shielding door	γ (mR/hr)	0.055	background	0.035	
	n (mRem/hr)	0.35	background	background	
Target Room 3 (controlled)	γ (mR/hr)	0.08	1		7
	n (mRem/hr)	0.1	1.2		12
Pipechase in Basement	γ (mR/hr)	0.30		0.12	
	n (mRem/hr)	1.5		background	

NRC monitors were located at the end of the appropriate beamline.

Beam stopped in Target Room 2

		STOPPING LOCATION/CONDITION			
MEASUREMENT LOCATION		60W Beam Dump	60W Wall valve	40W Faraday Cup	40W Wall Valve
Object Cup (controlled)	γ (mR/hr)	28	20	11.6	12
	n (mRem/hr)	544	398	212	216
Target Room 2 (controlled)	γ (mR/hr)	2650	442	5300	129
	n (mRem/hr)	130000	408	118000	1940
LE End (controlled)	γ (mR/hr)				.6
	n (mRem/hr)				1.52
HE End (controlled)	γ (mR/hr)				12
	n (mRem/hr)				400
Wall Valve (controlled)	γ (mR/hr)		5895		9200
	n (mRem/hr)		129000		192000

NRC monitors were located at the end of the appropriate beamline unless otherwise stated.

Beam Stopped in Target Room 4

		STOPPING LOCATION/CONDITION	
MEASUREMENT LOCATION		55 E Wall Cup	55E Diagnostic Cup
TR4 Emergency Wooden Door (hallway)	γ (mR/hr)	1	.8
	n (mRem/hr)	3.5	2.2
South wall patch (outside building)	γ (mR/hr)		background
	n (mRem/hr)		background
Roof	γ (mR/hr)	background	
	n (mRem/hr)	background	
TR3 behind power supply (controlled)	γ (mR/hr)	.2	
	n (mRem/hr)	background	
TR3 hole in wall (controlled)	γ (mR/hr)		background
	n (mRem/hr)		background

Beam Stopped in Target Room 4

		STOPPING LOCATION/CONDITION	
MEASUREMENT LOCATION		55 E Wall Cup	55E Diagnostic Cup
Object Cup (controlled)	γ (mR/hr)	16.1	10.4
	n (mRem/hr)	264	192
Target Room 4	γ (mR/hr)	48	4560
	n (mRem/hr)	640	96800

6/15/92

Tandem Van de Graaff Beam Fault Radiation Measurement Procedure

1. Purpose of Testing

- 1.1 To test the adequacy of shielding for the protection of personnel against the worst case beam induced radiation for the current machine configuration.
- 1.2 To determine the optimum locations for Radiation Safety System monitors.
- 1.3 To determine the relationship between radiation levels measured by these monitors and levels in adjacent areas.
- 1.4 To establish Operational Safety Limits (OSL's) relating to the generation of beam induced radiation at the TVDG Facility.

1.5 BASIS FOR A.I.Z. ACTIVATION

2. Testing Philosophy

- 2.1 MP-7 will be operated in a worst-case condition for the production of radiation (i.e. high energy deuterons).
- 2.2 A beam of known intensity will be intercepted at specific locations where faults might be expected to occur. Measurements will begin with a low intensity beam (<5 microamps).
- 2.3 Beam intensity will be increased and measurements made in adjacent areas.
- 2.4 Portable, calibrated radiation monitors will be used to check the area monitors.
- 2.5 Measurement results will be evaluated to determine if additional measurements should be made in more remote locations.

3. Responsibilities During Testing

- 3.1 The Test Coordinator will be appointed by the TVDG Safety Committee.
- 3.2 All setup and machine operation will be carried out by Tandem Van de Graaff (TVDG) personnel designated by the TVDG Operations Supervisor and under the direction of the Test Coordinator.
- 3.3 Measurements will be carried out by SEP personnel.
- 3.4 SEP will provide and prepare all monitors except for the NRC process monitors, which will be provided and prepared by the TVDG.
- 3.5 The Test Coordinator will make all decisions regarding beam current and species.

3.6 The Test Coordinator may approve appropriate deviations from the procedure specified below and make such changes in the measurement locations and fault conditions as required to achieve the purpose stated above.

3.7 The Test Coordinator may delegate any or all of the responsibilities to a designated substitute.

4. Testing Prerequisites

4.1 The Test Plan must be approved by the TVDG Safety Committee.

4.2 A tentative Testing Schedule must be agreed upon by the TVDG Operations Supervisor and SEP.

4.3 The Radiation Safety System must be in proper working order. Responses must not be compromised.

4.4 Area postings must be current and correct.

5. Precautions During Testing

5.1 The TVDG Operations Supervisor will train TVDG operators in the Testing Procedure and will complete attached form listing all those who have received such training. Individuals previously trained in the HITL/HTB Fault Studies Procedure will not require additional training. Only trained personnel will participate in the setup and operation of the accelerator for this procedure.

5.2 The SEP Representative will use the data generated by the test to evaluate the need for additional postings as beam intensity is increased.

6. Instruments Used for Testing

6.1 The following instruments will be used:

1. NRC Area Monitors Model ADM610 for neutrons and gammas
2. HPI1010 handheld survey instrument for neutrons and gammas
3. R02 handheld survey instrument for gammas.
4. Such additional instrumentation as required.

6.2 SEP will also provide a microrem meter.

7. Testing Procedure

7.1 Advance Preparation

- 7.1.1 Arrange for SEP coverage for the test.
- 7.1.2 Position the fixed area monitors as close to 0° and 3 ft. from each beamstop as practical.
- 7.1.3 Portable calibrated radiation monitors should be positioned to check area monitors via CCTV.
- 7.1.4 Radiation measurements for locations directly above beam stops in the accelerator room and the target rooms shall be made on the roof directly above the beam stop in question. These locations will have previously been marked.

7.2 Beam Setup and Tuning

The following beam will be generated using procedures in the TVDG OPM.

Species - Deuterium (1H2)
Energy - 28 MeV
Intensity - < 5 microamps

Adjust object and image slits to intercept as little beam current as possible.

7.3 Measurements (beam intercepted in Accelerator Room)

- 7.3.1 With equal beam currents (about 1 microamp) intercepted at the HE, OBJ and Image Faraday cups, record the radiation produced at 0°, 3 ft. downstream of each location, using portable monitors to check area monitors via CCTV.
- 7.3.2 Survey teams will be located at positions listed below. If insufficient personnel are available to cover all locations simultaneously, the procedure will be repeated until all areas are covered.
 - 1. HITL tunnel
 - 2. MP-6 (where and if possible)

3. MP-7 roof
4. Target Room 2 (adjacent to MP-7)

- 7.3.3 Intercept beam (about 1 microamp) at HE Faraday cup.
- 7.3.4 Record beam intensity and perform radiation surveys of areas designated above.
- 7.3.5 Evaluate the results to determine whether additional postings or precautions are needed, or if survey should be extended to outlying areas before increasing beam current. In particular, survey may need to be extended to Control Room and Target Rooms 3 and 4, depending on results from Target Room 2.
- 7.3.6 Increase beam current. Repeat steps 7.3.4 - 7.3.6 until maximum beam current is reached.
- 7.3.7 Reduce beam intensity. Intercept beam at Obj. Faraday cup. Repeat steps 7.3.4 - 7.3.6
- 7.3.7 Reduce beam intensity. Intercept beam at Image Faraday cup. Repeat steps 7.3.4 - 7.3.6, including Target Rooms 3 and 4 in list of locations. Measurements near MP-6 may not be possible due to radiation levels.

7.4 Measurements (beam intercepted in the Target Rooms)

The two active target rooms should have all the active beam lines tested. Beam will be intercepted at two locations in each beam line; upstream at the wall valve and downstream at the end of the line. The beam plugs will also be inserted to intercept beam and the target room surveyed.

- 7.4.1 Fixed area monitors will be positioned as close to 0° and 3 ft. from each beam stop as practical.
- 7.4.2 Reduce beam intensity and transport beam to the end of the target room beam line with maximum transmission.

7.4.3 Record the radiation produced at each location using the portable monitors to check the area monitors via CCTV.

7.4.4 Locate survey teams at the locations listed below. If insufficient personnel are available to cover all locations simultaneously, the procedure will be repeated until all areas are covered.

1. Control Room	The Test
2. Target Room 2	Coordinator will
3. Target Room 3	d e s i g n a t e
4. Target Room 4	required areas.
5. Corridor (hallway)	
6. Target Room Roof	
7. Building Equipment Room	

7.5 Repeat Section 7.4 for each active beam line.

Approved: Tandem Safety Committee

J. Benjamin	_____	date _____
C. Carlson	<u>C. Carlson</u>	date <u>6/15/92</u>
T. Robinson	<u>T. Robinson</u>	date <u>6/15/92</u>
K. Smith	<u>K. Smith</u>	date <u>6/15/92</u>
J. Throwe	<u>J. Throwe</u>	date <u>6/15/92</u>
F. Zafonte	_____	date _____

Tandem Van de Graaff Beam Fault Radiation Measurement Procedure Followup - 12/93

1. Purpose

To test the adequacy of shielding installed following the fault study of 5/92.

2. Concept

MP-7 will be operated in the most prolific configuration for the production of radiation (i.e. high energy deuterium). A beam of known intensity will be intercepted at specific locations corresponding to areas where additional shielding has been added. Measurements will be begun with a low intensity beam (< 5 microamps).

3. Responsibilities

All setup and beam operation will be carried out by Tandem Van de Graaff (TVDG) personnel designated by the TVDG Operations Supervisor. Measurements will be carried out by SEP personnel. SEP will provide and prepare all monitors except for the NRC process monitors, which will be provided and prepared by the TVDG. The Test Coordinator appointed by the TVDG Safety Committee will be the TVDG Operations Supervisor. He will make all decisions regarding beam current and species. In addition, he may approve appropriate deviations from the attached procedure and changes in the measurement locations and fault conditions, if such changes are indicated to achieve the purpose stated above. In his absence, he may delegate these responsibilities to a designated substitute.

4. Prerequisites

- 4.1 The plan must be approved by the TVDG Safety Committee.
- 4.2 A tentative schedule must be agreed upon by the TVDG Operations Supervisor and SEP.

5. Precautions

- 5.1 The TVDG Operations Supervisor will train TVDG operators in this procedure and will fill out the attached form listing all those who received such training. Individuals previously trained for Fault Studies Procedures will not require additional training. Only trained personnel will participate in the setup and operation of the accelerator for

this procedure.

- 5.2 The SEP Representative will use the data generated by the test to evaluate the need for additional postings as beam intensity is increased.

6. Instruments

The following instruments will be used:

1. NRC Area Monitors Model ADM610 for neutrons and gammas
2. HPI1010 handheld ^{and for SNOOPY} survey instrument for neutrons and gammas
3. R02 handheld survey instrument for gammas.

SEP will also provide a microrem meter.

7. Procedure

7.1 Advance Preparation

- 7.1.1 Arrange for SEP coverage for the test.

7.2 Beam Setup and Tuning

The following beam will be generated using procedures in the TVDG OPM.

Species - Deuterium
Energy - 28Mev
Intensity - < 5 microamps

Adjust object and image slits to intercept as little beam current as possible.

7.3 Measurements

With beam stopped at the stopping locations in Table I, make measurements at the corresponding measurement locations.

Approved: Tandem Safety Committee

J. Benjamin	<u>J. Benjamin</u>	date <u>12/17/93</u>
C. Carlson	<u>C. Carlson</u>	date <u>12/17/93</u>
K. Smith	<u>K. Smith</u>	date <u>12/17/93</u>
J. Throwe	<u>J. Throwe</u>	date <u>12/17/93</u>
F. Zafonte	<u>F. Zafonte</u>	date <u>12/17/93</u>

Table I

STOPPING LOCATION/CONDITION	MEASUREMENT LOCATION	γ (mR/hr)	n (mRem/hr)
TR4 Wall Cup <i>55° line</i>	TR4 Emergency wooden door (hallway)		
TR4 Wall Cup	TR3 behind power supply		
TR4 Diagnostic Box Cup	TR4 Emergency wooden door (hallway)		
TR4 Diagnostic Box Cup	South wall patch		
TR4 Diagnostic Box Cup	TR3 hole in wall		
TR2 60W Wall valve	TR3		
<i>40°</i>			